finishing

Journal

...NT APPLICATION, ELECTRODEPOSITION, VITREOUS ENAMELLING,
...LVANIZING, METAL SPRAYING and all METAL FINISHING PROCESSES

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metal **finishing** journal

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JOHN ADAM HOUSE
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THIS JOURNAL IS DEVOTED TO THE SCIENCE AND TECHNOLOGY OF PAINT APPLICATION, ELECTRODEPOSITION, VITREOUS ENAMELLING, GALVANIZING, ANODIZING, METAL SPRAYING & ALL METAL FINISHING PROCESSES. THE EDITOR IS PREPARED TO CONSIDER FOR PUBLICATION ANY ARTICLE COMING WITHIN THE PURVIEW OF "METAL FINISHING JOURNAL" AND ALL SUCH ARTICLES ACCEPTED WILL BE PAID FOR AT THE USUAL RATES.

Contents

ENDURANCE

A NOT uncommon feature of the correspondence columns of the daily Press are communications from inveterate claimants of the titles to hold obscure records. The claims advanced range over a wide field of human activities and include such variants as having heard a cuckoo calling on December 25, or having successfully shaved 473 times with a single safety-razor blade or having worn the same pair of nylon stockings every day for 17 months. It is not our purpose here to reflect on the motives which inspire the recording of such minor triumphs but to draw from the fact that they are deemed worthy of recording at all, the conclusion that endurance is a singularly rare commodity.

Even metal finishes are not excluded from the endurance records, as from time to time there will appear in the pages of a motoring journal, for example, the boast of a proud owner that the paintwork (or maybe even the chromium plating!) on his 1933 model is as good as new without ever having been restored. Usually of course such statements are accompanied by the familiar plaint that "They just don't make paint (or chromium?) like that any more".

Even more cynical in its approach is the view taken by some correspondents to the effect that long endurance is not in the best interests of manufacturers, much of whose business comes from replacement orders, so that early failure promotes sales.

Although we cannot claim to speak with more than a consumer's experience of the expectation of life of a razor blade, or, rather less directly, of a pair of nylon stockings, the question of paint life is one which is of considerable technical interest to this Journal and its readers. Over the past quarter-century the entire nature of paints has undergone a series of radical changes and developments. Whereas at one time the number of different types of paint was extremely small, and the materials used in their manufacture were all of natural origin, with all the variation in properties that this necessarily implies, present day paints have evolved into a great multiplicity of types, most of them utilizing the products of new organic syntheses.

In consequence it has become even more vitally important to the satisfactory performance of a paint coating that the correct type of paint be selected for any particular application, and that the manufacturers' instructions concerning pre-treatment of surfaces, priming coats and handling of the paint should be rigidly adhered to. Failure to use the desired pretreatment, or the appropriate primer, or the addition of incompatible solvents or oils to a specially formulated paint can only result in an unsatisfactory performance by the final coating in service.

Behind every paint marketed by a manufacturer of repute today there is a background of investigation and fundamental research, all aimed at making the product as fit as possible for the purpose for which it is intended and determining those conditions under which it can be expected to put up its best performance.

The conditions of service which modern paint finishes are called upon to endure are frequently so exacting that anything less than the optimum will fail rapidly. If one adds to this the fact that in the event of the untimely failure of a paint finish, the blame is almost invariably attributed to the material rather than to the method by which it was selected and applied, it is manifest that the marketing of finishes calculated to put up anything less than a satisfactory performance would be salesmanship of a very poor order indeed.

The large amount of money and effort expended by the paint industry in endeavouring to ensure the effective utilization of their products is in itself clear evidence of their good intentions with regard to performance.

Talking Points by "PLATELAYER"

TOPICAL COMMENT FROM THE MAIN LINES AND SIDE LINES OF METAL FINISHING

BRUSSELS SPROUTS

ANYONE who has visited Brussels recently must have been struck by the way in which the city is being, as it were, torn up by the roots, and vast areas now look like a battlefield. All this is in preparation for the 1958 Exhibition which will occupy a site of nearly two square miles inside the city. By all accounts, this will be a quite remarkable exhibition it will even have its own railway system using ground level and overhead trains. When it is all over, Brussels will be left with a magnificent road system which will do much to facilitate transport in the city. One of the pleasing things about the exhibition is that the British government—which is sometimes niggardly in these matters—is going to do us proud on this occasion. The official pavilion will cost some half a million pounds and an even larger industrial pavilion, occupying an area of 60,000 square feet, is being put up by the Federation of British Industries with the support of many industrial organizations.

Belgium is not only an important market to us, but the exhibition will attract visitors from all over Europe, so that it offers a unique opportunity for British industrial products to show themselves at their best to many potential customers who may be unfamiliar with them.

While it is to be hoped that the finishes of the products shown will not be neglected, it would be still better if an exhibit were to be organized in which the many new developments in British metal-finishing plant and processes could be shown. Here is an opportunity for one of the trade or technical bodies concerned to do a useful job for the industry and the country.

BRAIN WAVES

PERHAPS one of the most intriguing of modern sciences is cybernetics, which is the study of control and communications in machines and animals. One aspect of this subject is the investigation of how the human brain works, and although the whole field is still almost an uncharted one, some important findings have already resulted from measurements of the electrical activity of the brain. In particular, it has been found that certain slow electrical rhythms are characteristic of people who are prepared to take long chances, *i.e.*, greater than the general average of a ratio of between 1,000 and 10,000 to 1 in favour of success which most people require in everyday life before committing themselves to a course of action. These brain rhythms are found in individuals of exceptional courage, and also in immature and easily led types and in young delinquents. It remains to be seen whether in the future, candidates for jobs requiring courage and initiative will be subjected to test by the encephalograph to determine their suitability. Those without the characteristic rhythmic electrical activity will no doubt be advised to enter accountancy or the Civil Service, for instance, where an excessive capacity for taking chances is, to put it mildly, not required. One thing is not yet clear, however, and that is whether these brain waves are inherent in the individual or whether they can develop after years of conditioning.

The selection of personnel is probably the most difficult problem of all in an organization, and in fact many successful men probably owe more to an ability to pick their staff than to any other single factor. A means of mechanizing this operation even in part, may have startling repercussions.

AVOIDING THE BLUES

TESTS on the psychological effects of colour have been reported recently from the United States by the Colour Research Institute of Chicago, which seem to indicate that the most remarkable changes in human reactions can take place as a result of environmental colour. Workers handling black boxes showed fatigue and high incidence of sickness until the boxes were re-painted light green. Likewise the blood pressure and pulse rates of people working in red painted rooms rose and considerable discomfort was felt after a prolonged stay. In a blue painted room the occupants became sluggish and their rate of work slowed down. Yellow caused excessive eyestrain, while in green rooms people complained of monotony.

While there is much in this report, no doubt, the fact remains that there seem to be few colours left which are unlikely to have any adverse effect, and one is drawn to the conclusion that nobody likes to work much under almost any conditions! However, a general conclusion which the author has drawn from the report is that blue-greens are the most popular colours, greens are comfortable, while orange is rather tiring. It is also a matter of common observation that people feel warmer in "warm-coloured" rooms and *vice versa.*

There is little doubt that people are becoming much more colour conscious, which introduces new manufacturing problems; those contemplating the installation of new finishing plant would be wise to ensure that their equipment is as versatile as possible to cope with changing fancies.

Methods used in the Performance TESTING OF PAINT

by
W. V. MOORE, B.A. *

1. DRYING TIME

The methods devised for obtaining a reasonably accurate assessment of the performance of a painted coating under differing service conditions are numerous and varied, and are still the subject of some controversy concerning the extent to which their results can be correlated with service life. In the series of articles, of which the first instalment appears below, it is proposed to review the testing methods and equipment available and to discuss their respective applications.

THE BEST method of testing paint for durability is, undoubtedly, to apply it to the article for which it was intended and to use that article under normal service conditions. Unfortunately, this method is too time-consuming to be used except under exceptional circumstances, so that a series of laboratory tests have had to be devised to evaluate paint systems in a short space of time.

In addition to the durability of a paint, there are also certain other properties concerning which the manufacturer using the paint, as opposed to the customer using the finished article, requires information. It is often necessary to fit the painting process into a production line without disturbing the flow of articles along it. In such a case the paint requiring the fewest number of coats, or which dries the quickest, may be preferred to one which gives the greatest durability. In almost every case the resultant paint film is a compromise between durability, price, and ease and speed of application.

It is the purpose of this article to describe the general laboratory methods for testing paints, and to discuss the results obtained and their limitations.

The Measurement of Drying Time

The drying of a paint film is a continuous and complex process, so that any measurement of "dryness" is an arbitrary one and will depend on the method used, but two main stages are of importance. The first of these is the "surface" drying time and the second is the "hard" drying time.

At surface dry the paint film does not appear tacky when touched lightly with the finger and dust particles no longer adhere to the surface. In such a condition the painted article can be moved safely, but will not withstand knocks or scratches. The time taken to reach this stage can be measured easily and quickly by the following method:—

Clean silver sand which passes a 52-mesh sieve but is retained by a 100-mesh sieve is dropped from a height of six inches on to the painted surface to be tested. After one minute the sand is removed by brushing lightly with a soft camel-hair brush. For the paint to be surface dry it must be possible to remove all the sand without marking or damaging the film.

This test is quick and simple, but does require to be repeated at fairly frequent intervals for accurate estimation of drying time. In order to surmount this difficulty, several pieces of automatic apparatus have been designed. The Sanderson apparatus consists of a circular table on to which is spun a film of paint; the table rotates slowly and sand drops upon it from a hopper. The hopper moves slowly outwards as the table rotates, so that a spiral train of sand is laid. The surface drying time is obtained from the length of the sand trail which adheres to the paint and the speed of rotation of the table. Periods of up to twelve hours can be measured by varying the speed of the motor driving the table.

A similar type of apparatus employs a long strip of paint on to which a strip of lint is pressed by a moving roller; the length of the strip of lint adhering to the paint gives a measure of the surface drying time.

Both these methods, while having the advantage of continuous recording over the simple sand and brush method, suffer from the disadvantage of requiring quite a large area of paint of a uniform thickness. Furthermore, the results obtained are, in any case, limited by factors independent of the apparatus.

The reproducibility of results is determined, to a very large extent, by the thickness of the paint film, the surface to which it is applied, and the atmosphere in which it is drying. The first of these factors can be held constant by applying the paint

* *Cellon Ltd.*

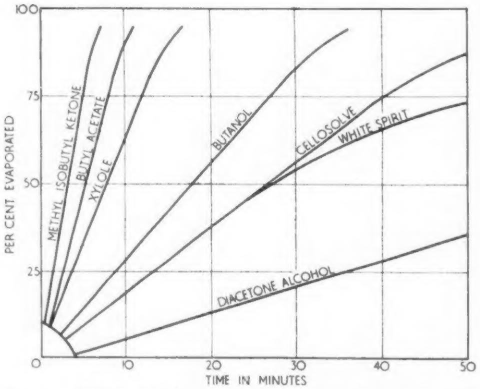


Fig. 1.—Graph showing evaporation rates of some common solvents.

with a "doctor-blade" to give a film of constant thickness, or by applying a specified weight of paint to a given area, while the second can be fixed by always using the same substrate. The effect of the atmosphere is much less easy to control, but tests should be carried out in a room with a constant temperature and humidity and out of the line of direct sunlight. There should be free circulation of air which must not be laden with solvent.

The reason for these factors affecting the reproducibility of results lies in the mechanism of drying. During surface drying, the primary process is the loss of solvent to the surrounding atmosphere which, if stagnant, causes the vapour pressure of solvent in it to rise as evaporation continues, and to tend to reach equilibrium with the solvent remaining in the film. Hence the rate of evaporation will be reduced and the drying time increased. Similarly, a decrease in temperature reduces the solvent vapour pressure and increases the drying time.

The thickness of the applied film affects the drying time by limiting the exposed surface area of paint. The amount of solvent evaporated in a given time is directly proportional to the surface area and so the rate of evaporation will be the same for a thick film as for a thin film. But since the thick film contains a greater weight of solvent than the thin film, its drying time will be longer.

The surface to which the paint is applied affects the surface drying by reason of its ability to absorb solvent. A completely non-absorbent surface will give a longer surface drying time, because all solvent must be evaporated from the surface of the paint. An absorbent surface will remove some solvent from the paint, leaving less to evaporate from the surface, and the film will quickly become surface dry. This does not necessarily mean that complete drying will be more rapid, since this absorbed solvent will tend to pass slowly back through the drying film as time goes on, thus delaying final hardening.

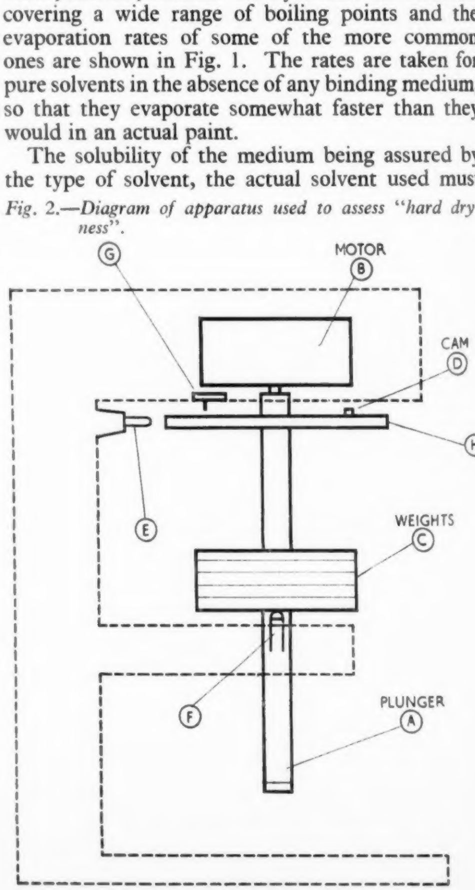
With these factors controlled, comparable drying times can be obtained between different samples, but it should be noted that these times may differ from those found in production where careful control of film thickness and air conditions is not possible.

The values obtained for surface drying time will vary from about five minutes for a quick-drying nitrocellulose lacquer up to about four hours for some high-gloss decorative finishes, although times of the order of five minutes will be approximate because of the appreciable time taken to perform the test. Since this time is governed mainly by the rate of evaporation of solvent, it is pertinent to enquire what factors govern the choice of solvents.

The first consideration is that the resins, plasticizers and other film formers shall be soluble in the chosen solvents. There is a wide range of esters, ketones, alcohols and hydrocarbons available covering a wide range of boiling points and the evaporation rates of some of the more common ones are shown in Fig. 1. The rates are taken for pure solvents in the absence of any binding medium, so that they evaporate somewhat faster than they would in an actual paint.

The solubility of the medium being assured by the type of solvent, the actual solvent used must

Fig. 2.—Diagram of apparatus used to assess "hard dryness".

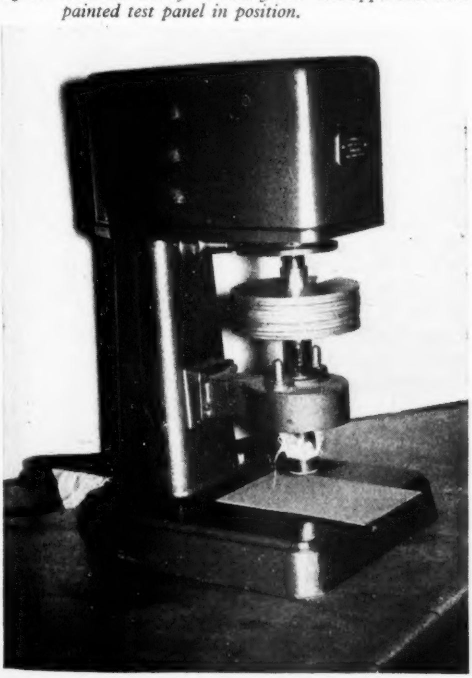


be chosen according to the way in which the paint is to be applied. Thus in a spraying lacquer the viscosity requires to be low for ease of application but high enough to prevent runs and sags on vertical surfaces. In order to achieve this, very powerful and volatile solvents are incorporated so that there is a rapid increase in viscosity as they evaporate, which prevents excessive flow. Further, less volatile solvents are then used to allow the paint film sufficient flow to give a smooth surface. Brushing finishes, on the other hand, must remain "open" under the brush while the surface is being covered and to allow adjacent areas to be joined. Rapid evaporation of powerful solvents with its consequent rapid increase in viscosity is therefore undersirable, and the solvent must have a lower evaporation rate. It is for this reason that the surface drying times of brushing finishes are longer than those for equivalent spraying types.

When the paint is to be applied by roller coating, dipping, or flow-coating, further problems occur. The paint is continuously open to the atmosphere, so that solvent can evaporate easily and, in the case of air-oxidizing paint, oxidation readily occurs. Thus slow evaporating solvents must be used to reduce evaporation losses, and slow-drying varnishes to prevent thickening or gelling of the paint during application.

Other solvents or diluents must also be added, irrespective of the method of application, to control

Fig. 3.—General view of "hard dryness" test apparatus with painted test panel in position.



final flow, bubbling, pin-holing and also price.

By the time the paint is surface dry, a large percentage of the solvent will have evaporated and in the case of air-oxidizing or catalyzed finishes, some polymerization will also have taken place. Polymerization and the loss of remaining solvent now continues, while the paint film gradually becomes harder and more insoluble until the paint is hard dry. However, the drying process does not stop abruptly at this point. Some solvent will remain trapped in the film and will continue to evaporate slowly for several weeks, while air-oxidizing finishes continue to oxidize for the whole of the working life of the paint. This prolonging of the final drying causes measurable changes in the properties of the paint in respect to hardness, flexibility and resistance to abrasion or corrosion, but for all practical purposes the paint is hard dry before these factors cease to vary. To measure the hard drying time, it is therefore necessary to fix an arbitrary time during the life of the paint film at which it has certain properties which can be said to constitute dryness. The point fixed is that at which the paint no longer prints or marks under pressure, so that the article painted can be moved and handled without damage. A method of qualitatively testing for hard dryness is to try and thumb-print the material—a test which is universally used and which seems to possess an irresistible fascination. This test can be standardized by using a "mechanical thumb", which applies a set load for a fixed period of time.

Use of Mechanical Thumb

The apparatus consists essentially of a vertical plunger $\frac{15}{16}$ in. in diameter, tipped with hard rubber and fitted with a platform so that it can be loaded with weights (normally 4 lb.). The hard rubber tip is covered with a piece of cotton twill with the rough surface outermost and held in position by a metal clip. This plunger and its associated weights constitutes the "thumb" and the remainder of the apparatus is concerned only with its presentation to the painted surface. Each test requires the following actions by the plunger: (i) The apparatus is switched on and the plunger starts to rotate; (ii) The plunger is lowered on to the test surface and there rests under its own weight; (iii) The plunger rotates through 270 deg.; (iv) Still rotating, the plunger is raised, rotates through a further 90 deg. and is switched off automatically.

The complete apparatus which accomplishes this series of actions is shown diagrammatically in Fig. 2. "A" represents the plunger which is driven by the electric motor "B". "A" is in two concentric parts which slide into one another like

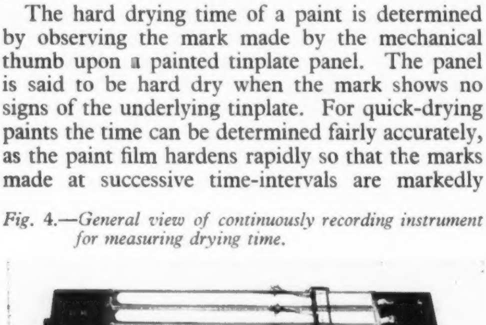
(*Continued in page* 56)

Testing of Paint
(*continued from page* 55)

a telescope, so that the lower half can be raised and lowered. The lower portion carries the weights "C". In the raised position "A" is supported by two pillars "F". When these pillars are lowered "A" drops under its own weight and rests upon the test panel. The lowering mechanism is operated by the horizontal cam "A" which is fixed to the upper half of "A". As "A" rotates "D" operates the switch "E" which is connected by a series of levers (not shown) to the pillars "F" and lowers them. After rotating through 270 deg. the cam once again comes into operation and raises the pillars so that "A" is lifted away from the test panel. The plunger "A" continues to rotate and would be lowered again during the next revolution, were it not for the stop "H", also attached to the cam, which operates a micro-switch "G" and stops the motor. The outer casing of the apparatus is shown by the broken lines. A general view of the apparatus with a test panel in position is shown in Fig. 3.

The hard drying time of a paint is determined by observing the mark made by the mechanical thumb upon a painted tinplate panel. The panel is said to be hard dry when the mark shows no signs of the underlying tinplate. For quick-drying paints the time can be determined fairly accurately, as the paint film hardens rapidly so that the marks made at successive time-intervals are markedly different. But for slow-drying paints it is rather more difficult to see precisely when the substrate ceases to show through the film.

Fig. 4.—General view of continuously recording instrument for measuring drying time.



This instrument, although not continuously recording, is extremely useful in that it always applies the same type of print, but the results obtained need to be supplemented by the observations of the operator. This is because some paints which appear hard dry under the instrument still retain a tacky surface which marks readily and so cannot really be considered hard dry. Nevertheless, the results do show up variations in the drying time of different paints of the same type.

Fig. 5.—Diagram of one of the arms, of the instrument in Fig. 4, in position on glass strip.

An example of a continuously recording instrument for measuring drying time is the B-K drying recorder, shown in Fig. 5.

The apparatus consists of six small arms carrying rounded needles which are freely pivoted about a horizontal beam. Under each of the small arms is placed a glass strip on which is the paint under test. When the apparatus is switched on, the horizontal beam is moved slowly along the length of the glass strips so that each needle traces a scratch along the paint film. The beam is operated by a screw driven by an electric motor, which is so geared that the full length of the strips can be covered in eight hours, twelve hours, twenty-four hours or forty-eight hours. Fig. 6 shows diagrammatically one of the small arms in position on its strip of glass.

The drying time of the paint is obtained from the length of the trace made by the needle upon the film, a scale being provided with the instrument which converts distance to time according to the gear used. The surface drying time as measured on this instrument corresponds to the distance along the trace in which the glass substrate is visible. During this time the paint is completely liquid and offers very little resistance to the moving needle, so that it rests upon the glass beneath. After this initial drying stage, the paint becomes set and the needle can no longer completely penetrate, although it continues to mark the film. This continues until the paint is completely dry and can support the needle without marking. The distance between the origin and the paint where the trace vanishes is the hard drying time.

This instrument offers great advantages by being continuously recording and by its ability to test six samples simultaneously and under the same conditions. The results obtained will not be the same as those for other methods since the measurement is not absolute.

The instruments described above show the type of apparatus which is used to measure the drying time of paints. Results obtained show good agreement between instruments of the same type, but not between instruments using different methods, since the point in the drying process at which the paint is said to be dried is selected arbitrarily. For strictly comparable results, all factors such as temperature, humidity and rate of flow of air, which can markedly affect the drying time, must be carefully controlled.

A Survey of AIR TREATMENT SYSTEMS in use in the Metal-Finishing Industries

by LEO WALTER, A.M.I.H.V.E., A.M.I.Plant.E.

The movement of large quantities of air and its treatment in various ways is a frequent necessity in workshops where metal-finishing processes are carried out. The nature of vapours and fumes arising from such processes make the subject of air treatment particularly important to the metal-finishing industry. It is intended in the short series of articles which is commenced below, to survey the methods and equipment currently available for the carrying out of such treatment.

The importance of adequate air treatment is effectively demonstrated in this view of a workshop where electroplated fittings are assembled. Undesirable fumes and vapours from the electroplating shop (indicated by arrow) which would adversely affect the working conditions in the assembly shop, are removed by a separate exhaust system.

THE supply and removal of air are important ancillary operations in many metal-finishing plants for example in spraying, pickling, plating, etc. Atmospheric cleanliness in coating operations requires special air-filtering methods, and efficient ventilation and air heating depends very frequently on the correct movement of very large volumes of air. The standard down-draught type of spray booth is an example of air movement required as part of a finishing process, whereby the incoming air may also be treated in several or all of the following ways: filtered, pre-heated, humidified, re-heated, and re-filtered. This process ensures that the air entering the booth is clean, has the right temperature and humidity, and is correctly distributed. Another air treatment encountered for synthetic painting plants is pressurization. For example, a plant consisting of a dry-off oven, a spray booth, a primer oven and an enamel stove may be totally enclosed, and the entrance vestibule to the spray booth, the booth itself, and the common vestibule to the spray booth and ovens may all be kept under a slight air pressure higher than other sections of the department. This prevents contamination by dust or dirt particles of the air in the finishing department as a whole.

The basis of air treatment is essentially fan engineering, and in the following text some factors of air movement by fans will be discussed.

Room Ventilation

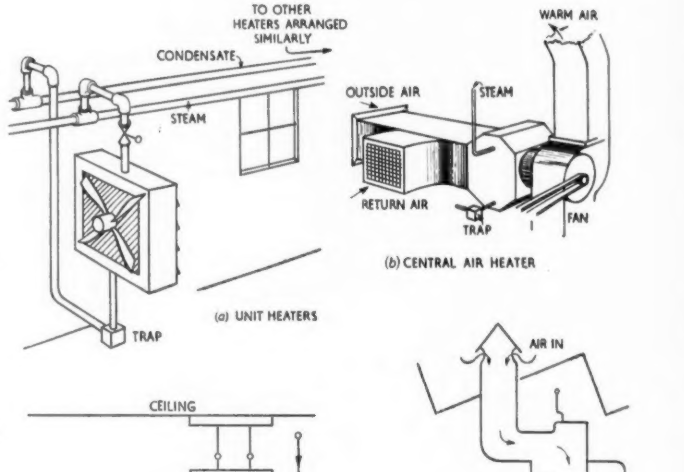
A finishing room or department must be ventilated, without causing cold draughts, especially during the winter months. The simple remedy against draughts is to close all apertures where cold air can enter a factory space. This would, however, be impossible in finishing departments where a certain minimum of air changes per hour are required by the Factories Acts. These air changes are important in order to keep the air continuously fresh, free from vapours, fumes, odours and impurities from solid particles (dust, grit, lint, fluff, etc.). Room ventilation is required for the whole factory, but the number of air changes varies according to local circumstances.

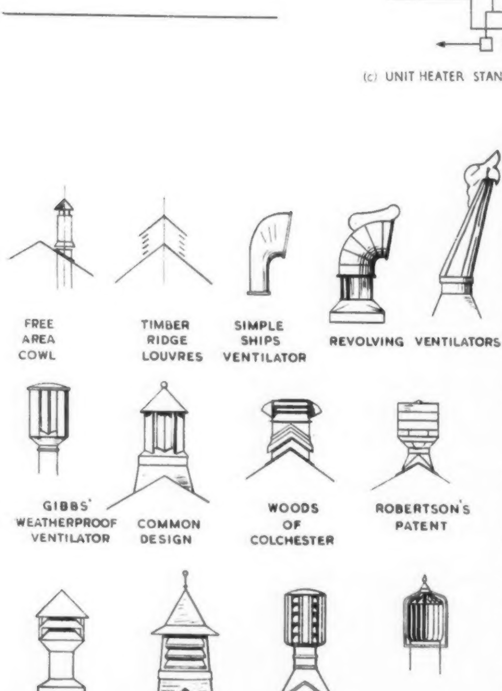
As is well known, stale air in a building can cause fatigue, with consequent lowering of output. The question whether a factory, or parts of a factory or workshop building are starved of air is not answered easily, and requires the services of an authority on the subject.

The welfare of factory workers, in general, is the responsibility of factory management, but the latter is supervised by conditions of hygiene and welfare

Fig. 1 (*Right*).—*Diagrams of unit- and central-type heaters.*

Fig. 2 (*Below*).—*Various types of roof ventilators.*





as set out in by-laws and regulations. It is apparent that the law cannot deal with every local condition, and in many instances interpretations are expected from technical plant executives. In general, adequate means of air circulation and of air temperature must be provided for those areas where metal-finishing operations take place and this applies especially where heat is generated, a steamy atmosphere develops, or where dust is created. The volume of the air supply, air cleanliness, air movement, avoidance of draughts, elimination of excessive air humidity, all fall within the general aspect of workshop or factory ventilation.

It should be noted that, at the same temperature, air of high humidity does not feel as cold as air of low humidity, because the latter causes increased evaporation of perspiration from the human body, an important consideration for factories in tropical climates. Some air movement is desirable inside a factory or shop even at low temperatures to avoid that "stuffy" feeling, but air speeds should be moderate. Convection currents in natural ventilation can be pleasant, but may become unpleasant if draught develops. In a modern factory ventilation system cold air is admitted at a low level, then warmed and admitted through grilles at high room level into the ventilated and heated space. Plenum heating systems are based on the above procedure

Balanced Air-pressure Conditions

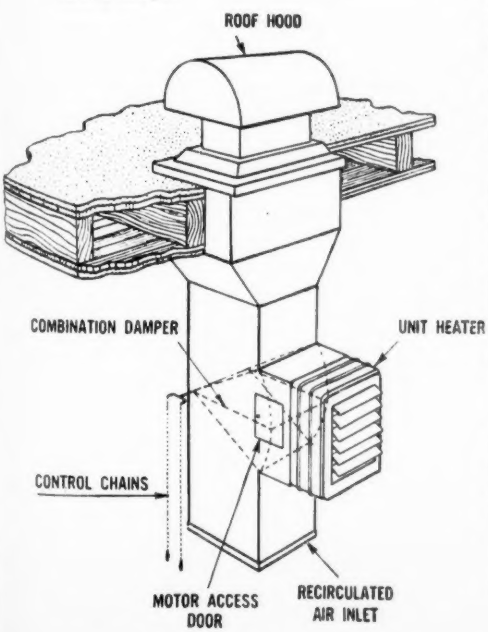
Air contamination from vapours emanating from process vessels or machines, increases air humidity, and requires the use of hoods, or of air ducting with hoods and exhaust fans. The partial vacuum created by the operation of mechanical exhaust equipment is often responsible for air starvation in a room or alternatively it may draw in cold air from outside through loose fitting or open doors and windows.

A good method to obtain balanced pressure conditions in a room together with an adequate temperature is to instal a unit heater with an open-air inlet and also a recirculation air duct. In winter the fresh air is brought in, warmed by heating coils and discharged draught-free in a good installation. During the summer months, the unit heater recirculates the air, with the heating medium (steam, hot water, gas, electricity) fully turned off, giving a fresh and cooling sensation to the workers (*see* Fig. 1).

Natural Ventilation

Ventilation by natural forces is available for moving air into, through and out of buildings, but it is not always easy to provide for means giving the right amount of air movement, and freedom from draught. Either natural wind forces can be used, or the temperature differential between inside and

Fig. 3.—Combined ventilation and space-heating unit, showing roof hood, unit heater, ductwork and control damper.



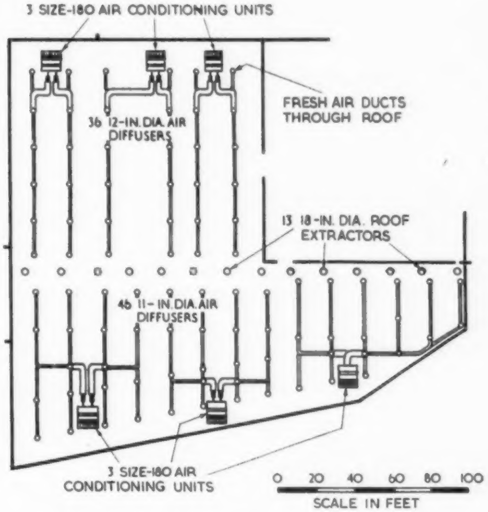


Fig. 4.—Diagram of large air-conditioning system.

outside air can produce some air movement. A scientifically-designed natural ventilating system has to be based on average wind velocities at the location of the building. Where the stack effect of vertical air ducts is used, it should be remembered that the rate of flow produced is approximately proportional to the height of a stack. The combined forces of wind and temperature difference are often used for roof ventilators, the function of which is to provide a storm- and weather-proof air outlet. The capacity of a roof ventilator depends, among other things, on location, its resistance to air flow, height of draught, and ability of the design to use wind energy, for example by rotation of the head. A general classification of roof ventilators can be made into stationary, oscillating, or rotating types (Fig. 2).

Incorrect installations of inlet and/or outlet air grilles, or of natural roof ventilators can cause a great amount of trouble. Some of the reasons for unsatisfactory results are: too small areas for air inlet or outlet; draught occurring at certain outdoor (weather) conditions; poor distribution of air; and bad location of roof ventilation units. It is preferable to seek authoritative advice, where conditions are bad.

The Use of Fans

Ventilation of rooms can be performed by means of fans blowing air into the room, or by exhaust fans which are widely used to remove stale or contaminated air from a space. In general, fan types range from simple propeller fans to heavy-duty multi-vane centrifugal fans.

A series of propeller fans exhausting to atmosphere through wall openings or *via* the roof will

(*Continued in page* 70)

FINISHING POST

A SELECTION OF READERS' VIEWS COMMENTS AND QUERIES ON METAL FINISHING SUBJECTS . . . . . .

Advice on all aspects of metal finishing practice is offered on these pages, and while every care is taken to ensure the accuracy of information supplied no responsibility can be accepted for any loss which may arise in respect of any errors or omissions.

Motor Generators for Plating Plant: Sir Ernest Canning states his views

Dear Sir,

The remarks of your correspondent "Platelayer" in your July issue referring to the position of generators against rectifiers has brought forward quite a lively correspondence from the U.S. The Chandeysson Company claim in your November issue to be the makers of the world's finest motor-generator sets and from the same issue one must presume that the Ford Company in the States are satisfied with something less than the finest, having purchased 80 sets from the Electric Products Company. It is contrary to our experience in this country because when the Ford Company buy equipment they go to much trouble to secure the best obtainable at the time.

The first generator on modern lines that we can trace for plating was imported by a firm of jobbing platers (previously working on batteries) from Hanson-Van Winkle-Munning Company in 1876. In the early '80s my own company bought a patent from Hemming and commenced the manufacture of generators. Over a period of 60 years we have achieved a name for generators because of their reliability, performance and durability. As an instance, I recently saw a Canning generator in use in the Southern Island of New Zealand that was supplied in 1898 and is still running today.

It is not the object of this letter to enter into the merits of rectifiers as opposed to generators, nor to enter into the claim that because American machines are built up to 20,000 amp. our 5,000-amp. machines are to be despised either on quality or price. As "Platelayer" has pointed out, leading British electrical manufacturers are in no way behind in the manufacture of motor-generator sets and although a 20,000-amp. machine would be beyond our capacity, there is no reason why such a set could not be produced should there be a demand, but leading British manufacturers of high voltage generators have had no compunction in buying Canning's low-voltage generators when the need has arisen.

As regards rectifiers, I should like to mention that my company is at present completing a contract for a 40,000-ampere rectifier unit for the steel trade. Another 50,000-ampere outfit with which we are acquainted is already running on rectifiers. During 1957 there will be brought into operation a rectifier equipment at a steel mill in this country totalling 435,000 amperes and still another on the Continent totalling 110,000 amperes. In such installations the choice of a rectifier is never made without previous advice from consulting electrical engineers and this is good proof of the excellence of the selenium rectifiers being made in this country.

The examples I have given, coupled with the statistics of rectifier manufacturers which reveal that every year rectifiers supplying many millions of amperes are being installed for heavy-current plating installations and that each year there is a rapid growth of rectifier applications, shows that generators are fighting a losing battle against rectifiers. With the introduction of the new semi-conductor rectifiers, germanium and silicon, it would seem that in the future the rectifier will even more certainly supersede the motor generator.

Yours faithfully,
ERNEST R. CANNING.

Chairman,
W. Canning and Co. Ltd.,
Birmingham, England.

Abrasion Testing

Dear Sir,

We have read the paper published in the January issue of your Journal describing some investigations into the abrasion resistance of vitreous enamel coatings, in the course of which the authors refer to the Taber Abraser.

As agents in this country for the Taber Instrument Co., we were somewhat surprised by some of the comments made in the paper concerning this equipment, which are not in accordance with the present-day position.

In the first place it was stated in the paper that ". . . the Taber abrasion test has practical limitations, particularly in the U.K., as special wheels are required which are obtainable only from the Taber Instrument Corp. (U.S.A.)". This is not correct, as the special wheels referred to are easily obtainable in the U.K. and as agents for the American company we have supplied a number of British-made wheels to Taber equipment users in this country.

The article also goes on to say that these special wheels have a short working life. We would

(*Continued in page* 66)

Galvanizing Practice at the Works of SMITH and McLEAN LTD.*

SMITH and McLean Ltd. operate as galvanizers at Mavisbank Works, Glasgow, and at Boundary Street, Port Glasgow; Mavisbank is the largest general galvanizing works in the country and this work has been taking place there for over 100 years. Whereas Port Glasgow works are only concerned with general jobbing galvanizing, however, Mavisbank also produces galvanized sheets, does metal spraying of all kinds, hot-dip tinning, and there is a large tinsmith and sheet-metal department.

The general galvanizing department handles all classes of product from large and heavy equipment to such small items as nails and washers. Classification of items galvanized ranges from tower work, pylons, coils, tubes, sheet-metal work of all kinds, shipwork, plumber pipes, and expanded metal to wire work.

To handle such a variety of work economically, baths of molten zinc varying from 36 ft. to 9 ft. long, 6 ft. to 3 ft. wide, and up to 6 ft. deep are required.

The hot-dip tinning mainly consists of cookery utensils and food containers for which a pure standard of tinning is required. The metal-spraying and shot-blasting department with its dust-extraction and air-conditioning plant, is well equipped to handle the variety of work to be sprayed.

Zinc is the most popular coating and items ranging from 14-ft. dia. fan wheels weighing 6 or more tons, 26-ft. long tanks, screens for hydro-electric schemes, large-diameter tubes down to nuts and bolts are all handled at the works. Mobile plant is available to undertake spraying at site where that is necessary.

The galvanized-sheet department galvanizes sheets as heavy as 10 B.w.g. and as light as 30 B.w.g. and narrow strips up to 60 in. wide.

Mavisbank Works has a railway siding and in addition operates a fleet of motor lorries (mostly of large capacity, carrying up to 15 tons) which are kept fully employed and, indeed, have to be supplemented by hired transport on occasion.

* *This description forms part of a comprehensive Technical Survey of the Colville Group of companies published by our companion journal, "Iron and Coal Trades Review".*

Galvanizing

The term galvanizing stems from Luigi Galvani's experiments and his theories enunciated in 1791, but it should be understood that the process of hot-dip galvanizing bears no relation to Galvani's theories (although the zinc coating protects the iron by electropositive action) and indeed Bablik(1) declares that the process used in what is called "hot-dip galvanizing" was described as early as 1742 by the French chemist Malouin. Bablik also states that galvanizing originated from the much older process of tinplate production. In any case, hot-dip galvanizing has the widest application in the prevention of metallic rust.

Lang(2) said *inter alia*, "Air is indispensable both to human respiration, or the formation of rust and other oxides . . . there is as you see a close

Fig. 1.—Diagram of sheet-galvanizing pot or kettle.

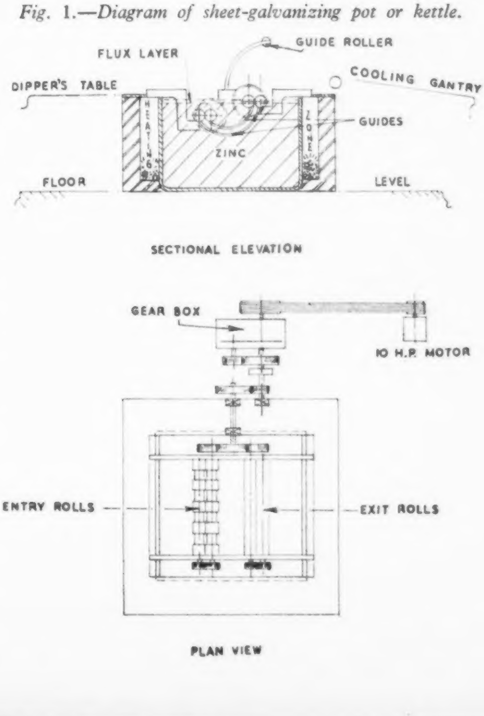


Fig. 2.—*A 12-ft. by 5-ft. tank being galvanized at the works of Smith and McLean Ltd.*

relationship between the processes of living and rusting, but while human beings make up for the rusting or decaying by nutrition, it has not yet been discovered how to feed or regenerate iron . . . so we are compelled to take our cue from the ancient Egyptians and resort to embalming."

Galvanizing may therefore be said to be a metallic form of embalming. The fact that zinc is the metal used to embalm the iron and steel is because, as has been stated already, it is electropositive to iron and sacrifices itself for the protection of the iron.

It must not be thought, however, that hot-dip galvanizing merely coats the iron although it is indeed bonded to the iron. To quote Bablik again: "The coating of the iron base with a film of zinc, thus takes place to the following part reactions: dissolution of the solid iron; combination of the zinc and iron to form solid iron/zinc compounds, the subsequent development of these layers taking place by diffusion of iron and zinc in these layers; formation of a coating of pure zinc on top of these alloy layers; and finally cooling down of the coating and crystallization of the pure zinc layer."

The Process

In general, the process of galvanizing is usually carried out in three stages: (*a*) Pickling in acid; (*b*) fluxing; and (*c*) dipping in molten zinc. There are variations within the first two headings from plant to plant, and sometimes even within plants, as to practice.

Some plants use hydrochloric acid (HCl) for pickling; some use sulphuric acid (H_2SO_4), and in the case of castings hydrofluoric acid may be used or, as is now common practice at modern plants, the castings may be shot-blasted. Fluxing may be done before the article goes to the zinc bath, or may be accomplished through a flux "blanket" on the top of the molten zinc.

(*a*) *Pickling:* The purpose of pickling is to remove scale layers and rust, but it should be understood that pickling will not remove paint or grease: therefore, if articles to be galvanized have such coatings, then a further process of preparation becomes necessary—degreasing by trichlorethylene and removing paint by burning or blasting. This fact frequently is not appreciated by people desiring galvanizing service.

Whether hydrochloric or sulphuric acids are used may be dictated by geographical considerations as much as by preference. In America, where the acids frequently have to be transported over long distances, sulphuric is extensively used because it can be obtained in concentrated form and is initially cheaper; but initial costs can be offset by the fact that whereas hydrochloric is effective at 60° F, sulphuric requires heating to between 140 and 180° F and washing is necessary after pickling in sulphuric acid: the washing is often done in hydrochloric acid.

Hydrochloric acid is used in these works, and is also used by most general galvanizers, and by many sheet galvanizers in this country. Tube galvanizers, on the other hand, generally use sulphuric acid.

Concentrations of HCl may vary considerably according to shape of articles, type of steel, time cycle of operation. The acid is usually received at 28 deg. Tw. (27·5 per cent. HCl by weight) and is then diluted with water according to requirements. The iron content of the pickle tank must be controlled, as iron salts affect the work seriously by adhering to the metal, being carried to the galvanizing bath.

Inhibitors are sometimes used to restrain the acid

attack on clean steel without affecting the rate of descaling, but galvanizers use inhibitors carefully as certain steels must be pickled more vigorously than others and inhibitors may retard pickling action.

Pickling tanks are built of various materials. The modern practice is to build them of acid-resisting bricks, but there are still in existence many pickling tanks built of wood set into puddled clay, and Yorkshire stone tanks are used where limits of length and breadth are not too great. Steel tanks covered with sheet rubber and protected by brick lining have also been successfully used for some time.

Sizes of tanks also, obviously, vary considerably according to the limits of material handled. At these works, for example, pickling tanks vary in length from 30 ft. to 40 ft. and in breadth from 3 ft. 6 in. to 6 ft., and in depth from 4 ft. 6 in. to 6 ft. are installed.

(*b*) *Fluxing:* Fluxing in hot-dip galvanizing is used for the same reason as it is used in soldering, *i.e.*, to obtain metallically bright and clean surfaces on the metals which are to react on one another. In other words, the flux removes all impurities from the iron surface to be galvanized and keeps the zinc surface of the bath free from oxides at the place where the article is immersed.

Where the flux is placed on the surface of the zinc bath and the article to be dipped is brought in a wet condition for immersion, the term wet-galvanizing is used. If the flux is applied to the article, then it must be allowed to dry before being dipped into the zinc and the term dry-galvanizing is applied. In wet-galvanizing the article is immersed in the zinc through a melted foamy flux, and in dry galvanizing the dried flux is melted and then foams as the article is immersed. Fluxes of sal-ammoniac and zinc chloride are commonly used.

(*c*) *Galvanizing:* Bath shapes and sizes are largely determined by the articles to be galvanized in them, and in a jobbing galvanizing plant it is normal to find several baths of different sizes. As already mentioned, this is the case in these works where the baths are constructed from Colville galvanizing quality steel. Heating of baths can be by coke firing or by coal, gas or oil, and in Sweden there is at least one electrically heated bath. Oil or gas or electricity have the obvious advantages of finer control and are infinitely cleaner to use. Coke, until recently, was cheaper and despite claims which are sometimes made to the contrary, long life can be achieved for a coke-fired bath where it is carefully supervised. Working heats for baths will vary according to the type of work being galvanized, but normal temperatures for working will not rise above 850° F and will sometimes be as low as 815° F.

It is common practice to have a layer of lead in the bottom of the galvanizing bath to facilitate the removal of the zinc dross from the bath regularly (usually once per week). But in any case a certain amount of lead will accumulate in the bottom of the bath as there is a small percentage of lead in G.O.B. spelter. Zinc dross, or hard spelter, is zinc with an Fe content (3·5 per cent. to 4 per cent.) and it accumulates as a product of the reaction between zinc and iron:—

(*a*) From iron salts carried to the bath by the article to be galvanized.

(*b*) Through the attack of the liquid zinc on the iron base of the article.

(*c*) Through the reaction of the liquid zinc with the walls of the bath.

In addition, the greater the temperature of the bath the higher becomes the Fe content of the dross, and if the temperature is too high the build-up of dross becomes heavy.

Dross is removed from the bath by means of a drossing tool—normally a perforated spoon or scoop. Failure to remove dross regularly and at short intervals will affect the quality of the work done, and an accumulation of dross will certainly lead to damage to the bath walls.

Dipping times vary according to types of material

(*Continued in page* 74)

Fig. 3.—*A* 12-*ft. by* 5-*ft. tank being withdrawn from the galvanizing bath.*

Research into

CORROSION AND ITS PREVENTION

Work in Progress on Show at S.C.I. Corrosion Group Exhibition

THE Battersea Polytechnic was the venue of another in the series of conversaziones staged by the Corrosion Group of the Society of Chemical Industry. This year's function was held on January 24, and in addition to the opportunity provided for discussion of corrosion problems over an excellent buffet supper, there was a showing of appropriate technical films and the customary exhibition staged by companies and research organizations, illustrating some of the methods and results of research into corrosion and its prevention.

Altogether eighteen organizations staged exhibits and descriptive notes covering the majority of these appear below.

The Armament Research and Development Establishment of the Ministry of Supply illustrated some of the varied investigations which are called for in the maintenance of military equipment, by showing a number of specimens of non-tarnishing "brass" buttons made of dyed anodized aluminium, contrasted with ordinary brass buttons. A micro-section of the dyed anodic coating showed adequate depth of penetration of the dye into the coating. Specimens of copper, which had been subjected to an anodic oxidation treatment, giving a dead black coating with good non-reflecting properties, were also on show. The process whereby these coatings are produced was described in a paper presented to the 1955 Annual Conference of the Institute of Metal Finishing and published in ***Tran. Inst. Metal Finishing*** 1955, **32**, 262. An electron micrograph of the surface of the oxide coating revealed that it possesses a "velvet pile" texture.

Work on phosphate coatings on steel was illustrated by a number of colour transparencies showing the prevention of the creep of rust under lacquer films by preliminary phosphate coating. A number of diagrams showed the protective properties of phosphate coatings produced in various baths, the variation of protective properties of coatings with treatment time in the phosphating bath, and the detrimental effect on the quality of the coating of copper contamination of a non-accelerating phosphating bath.

The copper spot test for determining the quality of phosphate coatings was demonstrated. In this test immersion of the coated sample in a solution of copper salt results in the deposition of metallic copper at uncoated areas of the surface, which are thereby clearly revealed.

Thickness Tester

Particular interest was evidenced during the evening in the "Drewitt" tester for determining the thickness of coatings which are softer than the metal base to which they are applied, *e.g.*, aluminium and zinc on steel, cladding on Duralumin, paint coatings on steel, etc. The instrument is extremely simple in operation; a special dental burr on a lightly spring-loaded spindle is applied to the coating and rapidly rotated by an electric motor. The movement of the burr to the coating is recorded on a dial gauge giving a direct reading of the coating thickness. A clearly defined end point can be obtained in the case of non-conductive coatings by placing an electric lamp in circuit with the burr and the specimen so that it lights up once the coating has been penetrated. This instrument was exhibited through the co-operation of Mr. F. E. Drewitt and Mr. D. W. Smith, I.E.M.E., Ministry of Supply.

Other exhibits on this stand included a descriptive chart showing how the protective properties of metallic coatings are related to their thickness and porosity, and methods of conducting determinations of porosity and average and local thickness of coatings. A number of corrosion specimens were shown, after two years exposure on a site in West Africa, showing the effects of various treatments and coatings under sea-coast and jungle conditions.

Another stand was devoted to showing researches which are currently in progress at the Battersea Polytechnic under the direction of Dr. L. L. Shreir. These included an apparatus developed to study the relation between film thickness, voltage and current during the anodic oxidation of uranium, and the use of a mercury contact to measure the electrical resistivity of phosphate coatings.

The British Iron and Steel Research Association illustrated researches on corrosion by water by displaying two pieces of apparatus, one designed for studying the effects of adding chemicals as corrosion inhibitors, and the other for testing the corrosion of iron and steel in water supplies. A five-minute film describing preferred practice in the painting of a gas-holder was shown continuously on this stand throughout the evening.

Certain substances used in the manufacture or processing of packaging materials are capable of giving off organic vapours under certain conditions of temperature and humidity. The work of the Chemical Research Laboratory in tracing this effect was illustrated by a number of exhibits on their stand showing samples of metal which had undergone heavy corrosion by the vapours of such substances as acetic acid and phenol given off by certain glues and plastics.

Use of Radioactive Tracers in the Study of Corrosion Inhibitors

Many compounds are known which, when present in sufficient concentration in an aqueous solution, will prevent the corrosion of certain metals immersed in the solution. The best known of such corrosion inhibitors are the chromates of alkali metals. Although much research has been carried out in many laboratories over many years, the precise mechanism by which chromates and other inhibitors prevent corrosion is still not fully understood.

In recent years, a very powerful tool, in the form of radioactive isotopes of many chemical elements, has become available for the estimation of small traces of these elements. Advantage is being taken of this technique at C.R.L. to study the mechanism of action of the chromates, using potassium chromate labelled with radioactive Cr (half-life 27·8 days, emitting gamma radiation).

Mild-steel specimens, 11 mm. square, are emeried and degreased, then immersed in solutions of labelled chromate for known periods. After removal from the solution, they are washed and dried, and the radioactivity on the surface is measured with a Geiger-Müller counter. Comparison with the count given by a standard containing a known amount of chromate enables the amount of Cr. on the surface to be calculated.

The uptake of Cr. by the metal surface has been studied in relation to various factors such as:

*p*H : n l concentration of solution;
time of immersion;
time of pre-exposure of the specimen to air, before immersion.

The latest results obtained by using these radioactive tracer techniques have made it possible to form a more complete and unified picture of the general mechanism of passivity and of room-temperature oxidation. Following on the demonstration that film growth in chromate solution and film growth in air both bear a linear relationship to the logarithm of time, it has now been shown that:

(1) The "logarithmic" film growth in chromate is preceded by the very rapid uptake of an amount of Cr. that is roughly constant irrespective of the age of the surface oxide film. This represents a film of the order of a monolayer in thickness, probably chemisorbed.

(2) The presence of oxygen in the chromate solution diminishes the rate of Cr. uptake and hence, presumably, of direct oxidation by chromate. This effect has not been suspected or taken into account in previous theories of passivity. It is assumed that the roles of chromate and oxygen as oxidizing agents are complementary, even though the concentration of oxygen is much smaller than that of the chromate ions. Chemical analysis of the stripped films is being carried out to check this hypothesis.

These results indicate that mild steel in chromate solutions acquires an adsorbed film immediately on immersion. This stage is followed by progressive film growth with an adsorbed film always present. The degree of protection (as shown by electrode potential decay curves) increases with increased film growth.

Film growth in air and in chromate solutions follows the same laws and is believed to be analogous in mechanism.

P. Hancock and J. E. O. Mayne (Department of Metallurgy, Cambridge University), are investigating the possibility of appraising the corrosive quality of aqueous solutions towards steel by an electrochemical method. The exhibit showed that anodic polarization curves have been obtained with twelve systems of mixed corrosive and inhibitive ions and it has been found that when compared with total immersion tests, the corrosive or inhibitive nature of the solutions could be estimated from the nature of the polarization curves, with only one exception ($NaNO_2$ and NaCl).

In several cases corrosion occurred in the immersion tests when the polarization curves indicated that the solution was just inhibitive, but the borderline between corrosion and passivity is not clear cut and there are reasons for believing that with solutions in the borderline region this method has a slight bias towards passivity.

Caution will have to be exercised in the interpretation of results obtained with small specimens in the laboratory, since the probability of corrosion increases with the size of the specimen and is affected by shape, *i.e.*, by the presence of crevices where the inhibitor may become exhausted.

Much more work will have to be done before this method can be considered to form the basis of an accelerated corrosion test.

Interest is currently being shown in the use of preparations of tannins as corrosion preventives. The Forestal Land Timber and Railways Co. Ltd. showed a number of tannin solutions formulated for use as primer paints for ferrous metal and as temporary protective coatings. A number of test plates showed the efficacy of these solutions as protective media.

A number of researches illustrated by T. P. Hoar and some of his co-workers (Department of Metal-

lurgy, Cambridge University), included apparatus for the continuous measurement of stress in electrodeposits (to be described in a paper to the Annual Conference of the Institute of Metal Finishing at Brighton next April), and a set-up for investigating the corrosion of stressed metals (to be discussed at a meeting in Brussels early in April.

The corrosion resistance of titanium was demonstrated by the Metals Division of Imperial Chemical Industries Ltd., by exhibits relating to a variety of test conditions in seawater, including impingement, rapid movement in the presence of abrasive particles, repeated stress, and contact with other metals. Included on the stand were tests to assess the suitability of the metal for various chemical engineering applications.

An exhibit shown jointly by Lewis Berger (Great Britain) Ltd., and Jenolite Ltd., comprised a selection of mild steel panels, the subject of tests carried out recently by Lewis Berger at their Homerton, London, laboratories.

The tests were designed to indicate comparative performances of Lewis Berger "Leadium" (metallic lead) primers on wire-brushed corroded steel, with and without treatment by a chemical derusting and phosphating process before painting. The process selected was Jenolite RRN/B. None of the panels received any undercoats or topcoats after priming. The tests, of unusual severity, consisted of humidity, salt spray and salt water immersion cycles, each of 800 hours.

Half of each panel exhibited was stripped down to the metal to show condition of the surfaces. In every case, the panel treated with the chemical process showed a striking superiority over its wire-brushed equivalent in condition of both paint film and steel surface.

Measuring Cathodic Polarization

The exhibit of the British Non-Ferrous Metals Research Association comprised two sets of apparatus currently in use on corrosion research. One of these was a multiple recording apparatus for measuring cathodic polarization in the study of the mechanism of corrosion by aqueous media. The other piece of equipment, use in investigating the mechanism of impingement corrosion, was a device for counting bubbles emitted by an air jet submerged in water. A beam of light was so directed that it impinged on the top surface of each bubble as it rose, and was reflected on to the surface of a photoelectric cell thereby triggering a relay counter.

Two complementary methods of studying the growth and constitution of oxide films on tin and tinplate were illustrated by the Tin Research Institute. In the first of these the thickness of the film was estimated by measurement of the quantity of electricity needed to reduce the oxide cathodically in air-free solutions of controlled *p*H value. In addition to the apparatus on which this work was carried out, examples of the potential/time periods which provide the evidence of the reduction of the oxides, and some growth curves for films were displayed.

In the second method the films are reinforced with an organic coating and then removed from the base metal by dissolving it in mercury. The films thus separated can be examined chemically and physically. Some examples of detached films with their reinforcement were displayed on the stand, together with results obtained from the examination of some samples.

From work carried out and evidence presented on the stand, it appears that the oxide which forms on tin when heated in air is stannous oxide.

Other firms exhibiting were Metal and Pipeline Endurance Ltd., whose exhibit emphasized the fact that the application of cathodic protection requires well-designed portable instruments for the necessary electrical surveys. A multi-combination corrosion and cathodic protection testing instrument was on show, together with other recent developments in test instruments.

Thermal Diffusion Coatings

Metallic Surfaces Research Laboratories Ltd., showed examples of coatings of chromium and other metals produced on metal surfaces by thermal-diffusion processes, and illustrated their resistance to oxidation.

The production of organic and inorganic crystalline coatings on ferrous metals, light alloys, and heat-resisting metals and alloys, including titanium and zirconium, was illustrated by the Pyrene Co. Ltd., while examples of powder spray coatings of metal and plastics were shown by the Schori Division of F. W. Berk Ltd. Among these were a number of test plates which had been sprayed with varying compositions of zinc-aluminium alloy, and subjected to exposure test.

Examples of the application of phosphate coatings and silicone-base resins to provide heat-resistant finishes were exhibited by the Walterisation Co. Ltd., while a number of test methods in use for assessing the protection given by wrapped coatings were demonstrated by Winnn and Coales Ltd. These included the CRL. beaker test, the Lloyd's tank method of assessing textile rot proofing agents, the McIntosh and Files jar for the study of sulphate reducing bacteria.

IT IS CHEAPER BY *TUMBLING*

Some Comments on American Experience in the Mass Finishing of Large and Small Components

by LEON E. LAUX *

WITHIN a period of two years, The Glenn L. Martin Company in the United States has increased the number of articles subjected to barrel tumbling from 1,000 to 30,000 a week. Once, only very small parts could be tumbled, but today, a wide range of components ranging from small clips and filler blocks to complex forgings weighing ten or twelve pounds are processed. Probably more than 1,000 different types of aircraft parts are now being descaled, deburred or finished by this universal mass-production method; the overall percentage of rejects is low, only 0·2 per cent.

Tumbling has been profitable to use, and the author estimates that the company's first large barrel (13 cu. ft.) saved 18,500 dollars during the first year it was in operation. A current aircraft contract involves approximately 28,200 details per ship. Of these, approximately 20,000 are suitable for tumbling. Savings over previous hand methods of deburring and finishing average 238 dollars per aircraft and this saving amounts to a substantial figure for the balance of the contract.

Costs Decline as Production Increases

During the initial development period, which began in January, 1954, the operational costs for barrel finishing were about 10 cents per component, *i.e.*, 40 per cent. above "break-even" costs for manual deburring. The "break-even" point of 6 cents per detail was reached by mid-August, and this level was continued until October. By the end of 1954, the average overall cost had fallen to 1 cent per detail.

A following study by the company's Standards-Methods Department showed that the tumbling operation could still be used more extensively, as a result of which the cost was reduced to $\frac{3}{4}$ cent per detail during 1955.

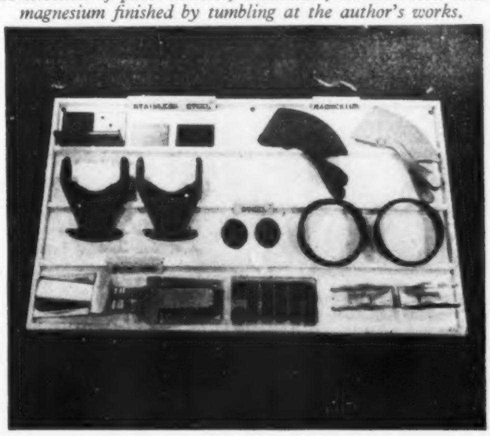
Starting at 1,000 machined details a week using the single 13-cu. ft. capacity barrel previously mentioned, by August, 1954, production had risen to the break-even point of 4,000 details per week. The weekly production today is between 25,000 and 30,000 details per week, and the present slope of the production curve is about 45 deg. The author sees no reason why this straight-line increase should not continue for a long time to come, and the original anticipated goal of 1,000,000 details to be tumbled annually has already been exceeded by 250,000.

Components Suitable for Tumbling

About 95 per cent. of the parts tumbled are aluminium alloys. Originally limited to small parts stamped from sheet stock, it is now possible to handle stampings, forgings, machined forgings, castings, formed parts and extrusions with equal facility. In addition to aluminium, steel, stainless steel, brass, copper, magnesium, titanium and even plastic parts, are now subjected to tumbling. It is also possible to tumble different parts in the same run and this is one of the reasons why costs have fallen. A full load for the tumbling barrel saves both man-hours and machine time as well as tumbling compounds and abrasives. However, it is not often possible to load a large barrel with identical parts. The automobile industry can do it as a matter of routine, but automobile production requires large numbers of identical parts. This is not so in aircraft production, which involves small lots but thousands of different parts.

In the main the tumbling process is used to

A selection of parts in steel, aluminium, stainless steel and magnesium finished by tumbling at the author's works.



Supervisor, Manufacturing Research and Development, The Glenn L. Martin Company, Baltimore, Maryland, U.S.A.

remove burrs, rough raised edges found on components after they have been stamped, sawed, machined, etc. Burrs are removed by rotating the parts in a barrel with proper sizes and amounts of fused aluminium-oxide chips, tumbling compound and water.

The purpose of deburring is fourfold:

(*a*) To minimize cracking. This objective is particularly important in the case of fatigue-sensitive materials that must undergo subsequent forming operations such as bending on a press brake or will be subjected to critical stresses under load.

(*b*) To smooth sharp edges that could cut or damage wiring, cables, hoses, etc. Not all sharp edges are burrs, but the deburring process will round off all the edges at the time the burrs are removed.

Like burrs, sharp edges often act as crack-sensitive starters on aluminium parts. When the part is bent on a press brake, the crack will begin at a corner and progress inward. By putting slight radii on the edges, it is possible to make crack-free bends.

(*c*) To assure positive mating of assemblies—holes in splices, etc.

(*d*) To prevent injury to workers who are handling details during manufacture.

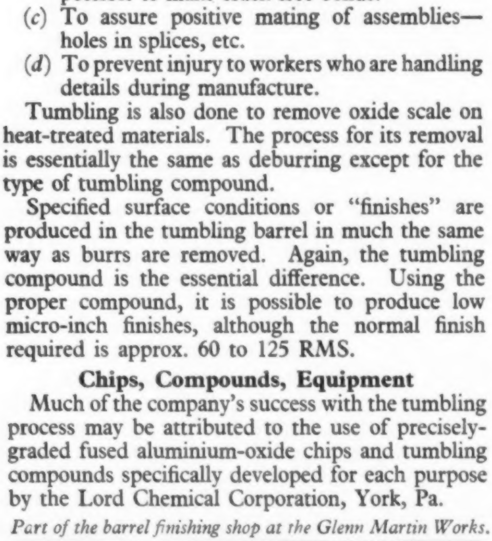
Tumbling is also done to remove oxide scale on heat-treated materials. The process for its removal is essentially the same as deburring except for the type of tumbling compound.

Specified surface conditions or "finishes" are produced in the tumbling barrel in much the same way as burrs are removed. Again, the tumbling compound is the essential difference. Using the proper compound, it is possible to produce low micro-inch finishes, although the normal finish required is approx. 60 to 125 RMS.

Chips, Compounds, Equipment

Much of the company's success with the tumbling process may be attributed to the use of precisely-graded fused aluminium-oxide chips and tumbling compounds specifically developed for each purpose by the Lord Chemical Corporation, York, Pa.

Part of the barrel finishing shop at the Glenn Martin Works.



Unloading a small barrel finishing machine.

Media sizes range from 00 (large chips of about 2 in.) down to 12 mesh, where the grains are akin to coarse sand. The chips used are pretumbled during manufacture and are ready for service when delivered. They are washed periodically to prevent them from clogging up with metallic particles and to ensure that there will be no contamination when switching from one compound to another. Chips gradually wear down and have to be regraded to smaller sizes. However, chips seldom fracture and even under heavy production, will last for a long time. One or more tumbling compounds are needed in each run.

The tumbling equipment in use includes:

Two 18-cu. ft., two-compartment barrels (9-cu. ft. on a side), capable of holding 500 lb. of chips per compartment.

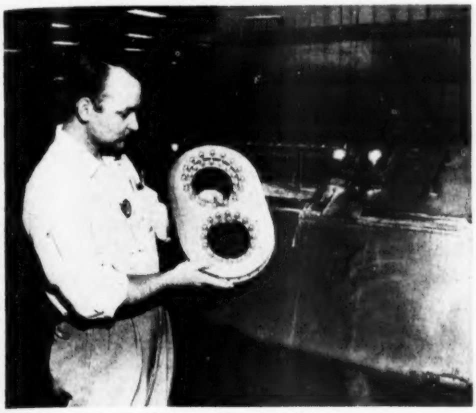
One 13-cu. ft. single-compartment barrel capable of holding 600 lb. of chips.

Two 5-cu. ft. two-compartment barrels ($2\frac{1}{2}$-cu. ft. on a side), holding 250 lb. of chips per compartment.

Four $1\frac{1}{2}$-cu. ft. burnishing barrels, not readily adaptable to deburring machined details. (The above constituted the company's original equipment.)

Two $\frac{1}{2}$-cu. ft., single-compartment barrels. Designed for bench tumbling, these barrels have compartments 12-in. in diameter by $7\frac{1}{2}$ in. wide. They are very useful when a load of small parts is to be tumbled at comparatively high speeds, *i.e.*, up to 58 r.p.m.

Even with the present wide variety of chips, compounds and equipment, not all parts can be tumbled, and at present, size is the chief limiting factor. Quite large pieces can be tumbled, but the advantage of quantity production is lost because so few large parts can be loaded into the barrel. It is planned to add more barrels as increased production warrants the investment and also to provide fixtures for tumbling large, heavy parts.



A typical part finished by tumbling by the processes described in this article.

To assist in judging whether or not a particular part is suitable for tumbling, a series of three process planning sheets has been prepared, one for extrusions, one for castings and forgings and one for sheet metal. These sheets tell at a glance whether or not a specific part is suitable for tumbling. Each planning sheet takes into consideration such factors as material (aluminium, magnesium, copper, steel), minimum and maximum thickness, maximum dimensions, and prior operations such as machining or drilling.

After consultation of the proper planning sheet, tumbling where required is specified on the write-up sheet that plans the sequence of production operations for each of the many thousands of individual parts that make up an aircraft.

At present, there is no applicable Government specification for barrel descaling, deburring and finishing of metal parts, but over a period of several years, working in close association with the Lord Chemical Corporation, the company has prepared a manual for the tumbling operators and supervisors. Most of the information that follows is condensed from this manual.

Preparation for Tumbling

Burrs are examined carefully before the tumbling of a part is started. Burrs up to 0·020 in. high are readily removed by short-cycle tumbling, if accessible to the media. Very heavy burrs are usually removed manually by filing, scraping, or sanding.

Another preliminary consideration is to determine the number of parts that can be safely loaded in a barrel. This may be ascertained from Table I. To use this table, the volume of each part must be computed in cubic inches, and when the volume of a particular detail falls between the sizes given in the table, the maximum barrel loading must be interpolated. As an example, for $2\frac{1}{2}$ cu. in., the maximum loading will be 750 parts. If the estimate cannot be interpolated readily, the next lower barrel loading figure from the table is used.

TABLE I
Barrel Loading

Size of detail in cubic inches	Maximum barrel loading	Size
2	900	
3	600	
4	450	
6	300	
12	150	Large barrel
18	100	
24	75	
30	60	
36	49	
48	37	
6	100	
9	65	
12	50	
18	35	
24	25	Small barrel
30	20	
36	15	
48	12	

When selecting media for a particular part, it is necessary to consider all recesses, radii, angles, fillets, slots, holes and intricate contours. The rule, however, is fundamentally simple: Select the chip size that will not wedge in the work. By comparing media of different sizes with the part, it can be determined easily which size will be best suited for the particular part.

When the parts are in the tumbling barrel, the total weight of the mass directly above a particular piece will be transmitted to that piece by the media at their contact points. The fewer contact points there are, the more pressure will be exerted on each point, and the deeper the surface scratches. Large chips can never produce as smooth a surface as smaller ones, because larger chips support a larger mass to bear upon the contact point.

As an example, to remove the burr from a $\frac{1}{4}$-in. radius on a soft Alclad surface, use chip size 4, from $\frac{3}{8}$ to $\frac{1}{8}$ in. This chip size is matched to the particular job.

Selecting the Tumbling Compound

It is of the utmost importance that the right compound be selected for the particular job to be done, and this involves no difficulty as a wide range of suitable compounds is available.

Basic Tumbling Procedure

After the barrel loading, chip size and tumbling compound have been determined, the basic tumbling procedure can be outlined in twelve simple steps:

(*Continued in page* 70)

It is Cheaper by Tumbling

(*Continued from page* 69)

1. Load parts and chips. Heavy and precision parts are loaded in layers. Light and non-precision parts can be loaded in the barrel on top of the media. In both cases, there should be a heavily built-up bottom layer of media.
2. Add water. Different water levels used in barrel finishing; these levels are based on a theoretical 50 per cent. barrel load.
3. Add tumbling compound.
4. Turn switch "on" and rotate barrel. A normal run to remove burrs from aluminium and magnesium parts is 30 minutes to 3 hours. To remove burrs from steel parts, a normal run is 1 hour to 4 hours. Barrel should be reversed periodically every half hour to 45 minutes.
5. When parts are being tumbled for the first time, inspect them frequently for nicking, marking or rough surfaces. If corrective measures must be taken, use one of the following:
   (*a*) Add wooden or rubber blocks to separate parts during tumbling.
   (*b*) Reduce the ration of parts to media.
   (*c*) Increase volume of total parts and media load.
   (*d*) Increase water level if nature of parts permits.
   (*e*) Employ a suitable mixture of large and small media.
   (*f*) Use tumbling compounds that provide a "cushioning" action on parts. This will reduce the effects of their contact with each other.
   (*g*) Check the load until barrel speed is properly adjusted. Nominal barrel speed is 5 to 10 r.p.m.; $6\frac{1}{2}$ r.p.m. for machined parts.
6. If parts are properly deburred, and this is all that the work card calls for, stop tumbling. Rinse, as necessary, and remove parts. If burnishing must be done, include operations 7, 8, 9 and 10.
7. Rinse load thoroughly.
8. Add burnishing compound and water to proper level. Media do not have to be changed nor parts removed from the barrel. The burnishing run is the same as the deburring run except that the water level and compound are different. For aluminium and magnesium, a normal burnishing run is from 30 to 45 minutes. For steel, about 60 minutes.
9. Check condition of parts. This is done before emptying tumbling compound so that additional tumbling may be done if needed.
10. Rinse if indicated.
11. Unload media and parts; then separate.
12. Dry. In this shop, precision and heavy parts are dried by forced air. Small parts can be centrifugally dried if handled carefully.

The above procedure is simple in theory, but in practice a very great deal depends upon the intelligence and skill of the operator.

As operators become more adept and develop more "know-how", more and more parts may be diverted from hand deburring to barrel tumbling.

Air Treatment Systems

(*Continued from page* 59)

provide the least expensive method of mechanical room ventilation. The ventilating effect is provided by fresh air entering a room to replace the air extracted. Air inlets and extracting fans of the propeller type should be so located that the replacement air moves evenly through the whole room. Satisfactory results may be obtained with inlets along one side wall and extract points along the opposite wall in shops no more than about 50 ft. wide. Other exhaust systems use extraction of vitiated air along the centre of the shop with air inlets on either side of the wall. Fans may be fitted in individual roof cowls, or central extract ducts may be installed in multi-story buildings. Fig. 3 illustrates a unit heater combined with a roof hood for ventilating and heating a finishing or storage department. Air can be drawn in from outside by the unit heater fan, be heated and blown into the room. An adjustable damper on the air inlet duct from the room allows air recirculation. Fig. 4 shows an elaborate air-conditioning system for a shed. Similar to a warm-air heating and ventilating system (plenum heating) the plant shown consists of air ductwork, heaters and coolers, air filters, etc. Six unit air conditioners are shown supplying treated air which will keep the shop, during summer and winter, under uniform conditions of air cleanliness, temperature and relative humidity. At certain points in the short air ducts from each unit air conditioner, air diffusers or distributor openings provide a draught-free supply of treated air to the space. Not shown are exhaust fans in the outer walls located at strategic points where fumes or vapours develop.

It is impossible in a brief survey to give detailed information on ventilating systems for factory space and in subsequent articles, special fans and ventilating systems for finishing departments will be dealt with.

(*To be continued*)

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CONTINUOUS ELECTROLYTIC OXIDATION OF ALUMINIUM WIRE AND STRIP

by
H. RICHAUD *

(*A Paper presented at the 6th International Mechanical Engineering Congress, Paris,* 1956.)

AT the beginning of the century, in 1911, the work of a Frenchman, De Saint-Martin, revealed the possibility of producing anodic oxide layers on aluminium, in sulphuric-acid electrolytes. Since that time numerous patents for improvements have been taken out, concerning particularly the electrolyte and the conditions of electrolysis. Among the more important processes, other than the sulphuric bath, are the oxalic-acid bath, and the Bengough process which utilizes a chromic-acid solution.

Different theories have been advanced for the anodizing of aluminium and at the present time it seems that the theory which is most widely supported is that which assumes that a layer of alumina is formed by the discharge of oxygen on the aluminium electrode according to the reaction:

$$2\,Al^{++++}\,3O^{--} = Al_2O_3$$

The oxide film grows due to the chemical attack by the electrolyte which creates pores in the layer of alumina and renders it permeable to an electric current.

The porosity of the electrolytic oxide film plays a very important part in the properties of the film and its application:

(*a*) The flexibility of the oxide film is a function of the size of the pores.

(*b*) The alumina film can adsorb colouring agents by simple immersion in a dyeing vat, in the same way as cloth.

(*c*) The alumina layer may be sealed up by treatment in boiling water which transforms the γ alumina according to the reaction:

$$Al_2\,O_3\,\gamma + n.\,H_2O \rightarrow Al_2O_3,\ n.\,H_2O$$

producing a dilation of the layer and therefore a contraction of the pores. The sealing up may also be effected by means of waxes, certain greases or varnish, etc.

The oxidation of aluminium has extended very considerably from the industrial point of view, but it is still most frequently carried out statically, *i.e.*, by immersing the articles in an electrolyte. Such a method, although justified for relatively bulky articles, is not suitable for small articles and is impossible to use for wire or strip of great length, hence the necessity for using a continuous process.

Two continuous methods are used according to whether the objective is electrical insulation or decoration.

Oxidation of Wire and Strip for Electrical Insulation

With this process the objective is to produce an oxide layer possessing maximum flexibility and dielectric insulation. Furthermore, in order to make the process economic, it is essential to attain a considerable rate of production without using excessively long treatment baths, hence the necessity for working at high speed and for oxidizing the wire in long lengths. It has been found possible to obtain these results using a suitable electrolyte and conditions of electrolysis.

The oxidation bath, patented by Cie PECHINEY, has a sulphuric electrolyte containing chlorides whose purpose is to increase the porosity and, as a result, the flexibility of the oxide layer.

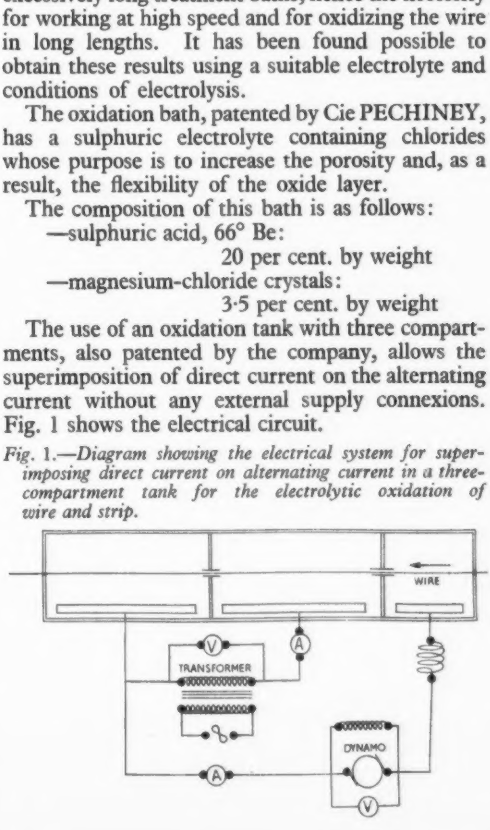
The composition of this bath is as follows:

—sulphuric acid, 66° Be:
20 per cent. by weight

—magnesium-chloride crystals:
3·5 per cent. by weight

The use of an oxidation tank with three compartments, also patented by the company, allows the superimposition of direct current on the alternating current without any external supply connexions. Fig. 1 shows the electrical circuit.

Fig. 1.—Diagram showing the electrical system for superimposing direct current on alternating current in a three-compartment tank for the electrolytic oxidation of wire and strip.



* Chambery Research and Physical Testing Department

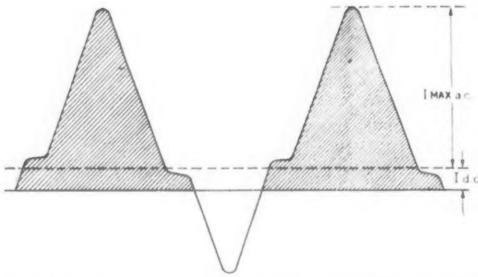


Fig. 2.—Diagrammatic representation of the wave form obtained by superimposing direct current on alternating current.

This process operates at alternating current densities of up to 200 amp. per sq. dm.; the superimposition of the direct current in certain proportions (approximately 1/5th of the alternating current) inreases the breakdown voltage of the resulting oxide layer.

Fig. 2 shows the positive and negative waveforms when a direct current is superimposed on an alternating current, the shaded portions corresponding to the oxidation zones, *i.e.*, where the oxide layer is building up. On the contrary the negative part of the wave is a zone where the oxide layer is only subjected to chemical action by the bath, which increases the size of the pores and thus the flexibility of the layer.

Description of the Oxidation/Impregnation Installation

This installation is shown diagramatically in Fig. 3. The length of wire, unrolling from the reels placed on the feeder, enters a pickling bath of composition:

—sulphuric acid, 66° Be.:
25 per cent. by weight approx.

—sodium fluoride:
1 to 2 per cent. by weight approx.

This pickling operates at about 80° C, its purpose being to eliminate surface impurities in the wire; normally, with a wire in the correct surface condition a treatment of 10 to 15 seconds is sufficient to achieve a surface suitable for electrolytic oxidation. After washing the wire enters the 3-compartment oxidation tank.

For a bath of 4-metres total length a normal oxide layer of 6 to 8 microns may be formed working at a speed of 4 to 5 metres per minute at an alternating-current density of the order of 80 amp. per sq. dm., and a voltage of 20 to 40 volts in general. The temperature chosen is between 18 and 25° C.

The oxidation treatment is followed by copious washing, and by drying at 60° C.

The wire, oxidized and dried, then enters a varnish bath which impregnates the pores of the alumina layer; the excess of varnish is wiped off by means of a piece of felt placed at the exit from the tank. The varnish is polymerized by passing through a furnace, then the wire is wound on to reels on the coiler placed at the exit end of the line.

Properties of Oxidized/Impregnated Wire

Normally the wire is covered after oxidation by an alumina coating of 6 to 8 microns which allows the following dielectric characteristics to be guaranteed on oxidized and impregnated wire having no excess layer of varnish, the varnish being there solely to seal up the layer without appreciably increasing its dielectric characteristics.

Dielectric Breakdown Test on "Platted" Wires

Two lengths of wire approximately 0.5 metres long are platted at a pitch of 8 to 10 times the diameter of the wire, and an alternating current is passed through them, the voltage difference between the two wires increasing until the point of dielectric breakdown is met.

The following values may be guaranteed:

—wire of diameter less than or equal to 1·5 mm.: 250 volts.

—wire of diameter greater than 1·5 mm.: 200 volts.

In addition, during this test, the alumina layer must not scale.

Dielectric Breakdown Test Between Wire and a Metal Mandrel

Three turns of the oxidized wire of diameter d are wound on a mandrel of diameter D such that D = 20 d. The winding is carried out without torsion, the free end of the wire being maintained by a weight P such that P = 600 d, P being expressed in grammes and d in millimetres.

An alternating current is then applied, the voltage difference between the core of the wire and the mandrel increasing up to the point of dielectric breakdown of the layer (*see* Fig. 4).

The following values may be guaranteed:

—wire of diameter less than or equal to 1·2 mm.: 120 volts.

—wire of diameter between 1·2 and 2·5 mm.: 90 volts.

—wire of diameter greater than 2·5 mm.: 60 volts.

The dielectric breakdown voltages obtained depend not only on the thickness of the alumina

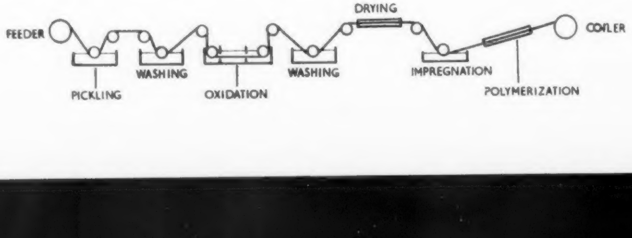
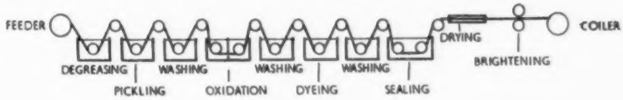
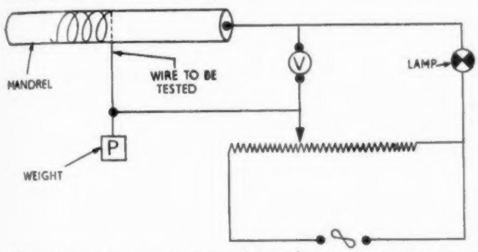


Fig. 3.—Diagram of the continuous treatment plant showing the succession of treatments applied in the production of impregnated oxidized wire.

Fig. 4 (below).—*Wiring arrangement for the measurement of the dielectric breakdown voltage of an oxidized coating on wire using a metal mandrel.*

Fig. 5 (right).—*Diagram of the continuous treatment plant showing the succession of treatment applied in the production of oxidized and coloured strip.*





film, but also on the surface condition of the wire used; it is essential, in order to obtain good insulation, to use wire particularly free from jagged projections and inclusions.

Flexibility

The oxidized/impregnated wire possesses good flexibility; in fact a wire of diameter d may be bent over a mandrel of diameter D, such that D = 10 d, without scaling of the oxide layer.

Temperature Resistance

One of the principal characteristics of the oxidized wire is that it maintains its insulating properties at high temperature, arising from the fact that alumina itself stands up to heat very well. Dielectric breakdown tests carried out on 1-mm. wire have shown that this oxidized wire retains its dielectric strength up to 600° C. If the wire is oxidized and impregnated, the varnish carbonizes at about 200° C, but as the alumina film remains intact the dielectric properties of the wire are maintained.

Applications

Oxidized wire has found numerous applications in widely differing fields; this is especially the case for windings likely to be subject to high temperatures, such as windings for contactors, demagnetizers electro-magnets, etc., etc.

Oxidized wire also finds use, by virtue of the saving effected, in shot-firing equipment in mines or for low-voltage motor windings, for example, automobile windscreen-wiper motors.

On oxidized/impregnated wire with an excess coating of varnish, the intervening layer of varnish increases the insulation; this wire may be used, by virtue of the saving achieved compared with enamelled copper, in windings working under high voltage, but which are not likely to operate at high temperature.

Oxidized/varnished strip can be used for canning. In this case a light oxidation of the order of one micron is effected to serve as a retaining base for an appropriate varnish, applied by roller to the surface of the strip; the varnish is then dried and subsequently polymerized.

Oxidation of Wire and Strip for Decorative Purposes

In this case it is necessary to produce a very flexible oxide layer to withstand, in particular, pressing operations, and yet sufficiently thick to be dyed; in addition this layer must be colourless in itself so as not to affect the decorative treatment. It is also very important, from the economic point of view, to effect the treatment at high speed.

The sulphuric bath which gives transparent oxide films is particularly suitable, especially for producing pastel shades, and to obtain good flexibility of the film alternating current is used which allows the production of more porous oxide films than does direct current.

Description of the Plant

This plant is shown diagrammatically in Fig. 5. The wire or strip passes first of all through a degreasing bath, containing say trichlorethylene, with felt wipers at the exit from the tank to avoid excessive carry-over of the solvent; then pickling is carried out in a sulphuric/hydrofluoric-acid bath for a few seconds at temperatures which may vary between 50 and 80° C according to the surface condition of the metal. When a special decorative appearance is required the pickling may be replaced by chemical brightening in a phosphoric- and nitric-acid base bath.

After washing, oxidation is carried out in a 20 per cent. by weight sulphuric bath, in a 2-compartment tank with liquid current pick-up. In a tank of 4-metres total length, oxide films of 2 to 4 microns may be obtained, working at speeds of the order of 3 metres per minute, at current densities of 6 to 10 amp. per sq. dm., or a voltage of 20 to 40 volts in general. The temperature chosen may be between 20 to 30° C and preferably between 25 and 30° C, so as to obtain oxide films which are very porous and consequently very flexible and more suitable for colouration with bright shades.

After washing the strip passes through the dyeing vat; this treatment is carried on for 10 to 15 minutes at 60 to 65° C. The strip is then washed followed by sealing in boiling water for about 15 minutes. Washing is followed by drying in a furnace at about 100° C, then by brightening which is effected by rotary nylon brushes placed in front of the coiler.

Galvanizing Practice at Smith and McLean Ltd.
(*Continued from page* 63)

and although good practice dictates that articles should be in the bath for as short a time as possible, awkward shapes and constructions frequently frustrate the galvanizer in his efforts to reduce the dipping time to what he knows to be correct.

Thus, whereas at a sheet galvanizing bath (dipping steel sheets by means of a galvanizing machine) it is possible to galvanize a large tonnage per hour in a bath containing 35 tons of zinc, it is only possible to galvanize a much reduced quantity per hour at a bath containing even 150 tons of zinc because of the awkward shape and construction of articles such as tanks with baffle plates, or complicated ducting.

Handling equipment also varies from plant to plant and even from bath to bath. E.O.T. cranes are used in these works at the larger baths (supplemented on occasion by jib crane) while at the small baths dipping is done by hand. Runways are also used.

(*d*) *Coatings:* Daeson(3) gives the build up of the coatings in layers represented by: (1) Fe_3Zn^{10} (or perhaps Fe_5Zn_{21}); (2) $FeZn_7$; (3) $FeZn_{13}$; and (4) Zn.

Whereas in sheet galvanizing thickness of coating can be controlled to some extent and weights of zinc coatings from 1·0 oz. per sq. ft. to 2·5 oz. per sq. ft. of sheet can be given, in jobbing work weight of zinc per sq. ft. of steel will be heavier, and depends on temperature of zinc, time of immersion, rate of withdrawal, class of steel, and shape of article. As will be readily recognized, a steel sheet can be passed through a zinc bath by machine at a controlled speed (speeds will vary according to gauge), but a fabricated tank of, say, $\frac{1}{8}$-in. thick sheet with $\frac{3}{16}$-in. flanges and stiffeners, heavy bosses and perhaps baffle plates inside (making manipulation in the zinc more difficult), is a different problem entirely; rate of entry is necessarily slower, time of immersion is longer, and rate of withdrawal is complicated by the shape of the article which can make draining difficult.

Electrolytic Oxidation of Wire and Strip
(*Continued from page* 73)

Results and Applications

The best results are obtained with oxide films of 2 to 4 microns. In fact, oxide films of less than 2 microns are too thin to permit of colouring with sufficiently distinct shades; on the other hand films greater than 4 microns are not suitable for deep drawing.

The oxidation temperature is a factor of great importance for this application as it controls largely the porosity of the film, *i.e.*, the flexibility and response to dyeing. Thus by working between 25 and 30° C instead of 20° C (temperature generally used for static oxidation) oxide films very suitable for colouring are achieved. As an example with all other conditions of electrolysis remaining unchanged, the increase in the electrolyte temperature from 20° C to 25 to 30° C has enabled practically all colours to be obtained by this process, including black which is difficult to obtain on thin oxide films.

The decorative appearance of the oxidized/coloured strip is largely a function of the surface condition and purity of the metal used. The higher the purity, the greater the degree of transparency of the oxide and in practice it is advisable to use aluminium of at least 99.5 per cent. purity.

As far as surface condition is concerned, the strip should be free from rolling defects such as inclusions, jagged projections, etc., all of which are shown up by anodizing. Among the many applications for oxidized/coloured wire and strip, the manufacture of necklaces, bracelets, etc., may be mentioned.

Oxidized/coloured strip is also used for the pressing of small articles such as bottle caps, lamp holders and name plates.

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Finishing Post
(*Continued from page* 60)

certainly refute this statement as these special wheels have the same life span as any other abrasive wheels. Furthermore, a diamond refacer can be supplied with the equipment for the truing of wheels that have worn out of round.

It is also worth pointing out that the equipment illustrated in the paper is a model of the Abraser which has been obsolete for many years.

We enclose with this letter a photograph and description of the current model of the Taber Abraser.

Yours faithfully,
S. DAVEY.

Funditor Ltd.,
Woodbridge House,
3 Woodbridge Street,
London, E.C.1.

The points raised in Mr. Davey's letter will doubtless be of considerable interest to those of our readers concerned with the abrasion testing of finishes, who were not aware of the availability of Taber equipment in this country. A description of the modern version of this testing equipment is published in the section of this issue devoted to new developments in plant, processes and equipment.

An Account of VITREOUS-ENAMELLING PRACTICE in a Danish Works

by O. SCHROEDER†

(*A paper presented at the 2nd International Enamelling Congress*)

THE state of vitreous enamelling in the Scandinavian countries was discussed in a recent paper by Gray.* The information given therein was quite comprehensive and it is not intended to recapitulate what was written by Mr. Gray.

In this paper it is proposed to give a short description of methods and problems of the enamelling plants in the author's factory *viz.*, D.F.J.

Danish vitreous enamellers have not yet formed a technical association which would make it possible for them to exchange experiences on enamelling problems. Therefore, the main source of knowledge about new developments in enamelling is the technical literature, emanating from Great Britain, U.S.A., Germany, and other countries.

Personal contact, is obtained through frit-suppliers, and this is of great value in solving the problems, which—as is quite normal in vitreous enamelling—are many. However, visits to other countries and personal impressions of production methods in foreign plants are of greater value. This is the reason why Danish enamellers come abroad and make contributions to further knowledge relating to their conditions and production methods.

Historical Facts About D.F.J. Enamelling Practice

The vitreous-enamelling traditions of this company, in which the author is employed, began in 1842 when Mr. Anker Heegaard, owner of an iron foundry in Copenhagen, started to produce vitreous-enamelled cast-iron pots for household purposes.

Through a hundred years this production developed and became well known in Scandinavia because of its high quality. It can be mentioned that recently a farmer's wife presented our museum with an old enamelled cast-iron pot, which had been in daily use since 1870. The enamel was still in perfect condition.

In 1858 Mr. Heegaard bought the armament factory in Frederiksvaerk from the Danish Government and re-equipped it for his own production requirements.

In 1890 he started the production of enamelled sheet-iron household utensils; this part of the company was sold to a competitive firm in 1913.

The old traditional way of enamelling cast-iron pots was maintained until 1933, when sandblasting instead of pickling and new formulae for frit-making were adopted. Until then the pots had only been enamelled inside using a matt groundcoat which was fired in an " inert " atmosphere, the pots being pushed top down on a plate through a muffle furnace of the tunnel-type to avoid oxidizing during firing. On the groundcoat a white covercoat was applied and on the outside the pots were painted with black varnish. From 1933 the demand for a better outside finish on the pots made it necessary to omit the old matt groundcoat. Instead, an annealing groundcoat was used, and, the pots were made grey-mottled inside and with a range of colours outside.

For frit melting the raw materials were weighed according to a secret formula, mixed in heaps on the floor and melted in a box-type furnace.

During the last war the scarcity of raw materials gave rise to the use of ground glass instead of borax, but although it was usable, the products were of poorer quality.

After the war—in 1948—the company ceased producing their own frits and started buying from English and Dutch frit makers. All other Danish enamelling works have followed the same practice.

Vitreous-enamelling Capacity in Denmark

In Denmark there are today about a dozen enamelling works producing about 2,500,000 kg. of enamelled cast iron and about 2,000,000 kg. of enamelled sheet iron, mainly household appliances, stoves, cookers, refrigerators, etc. The

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† Enamelling Plant Manager, United Iron Foundries Ltd.

* Vitreous Enamelling Industry in Sweden, Denmark and Finland. *Proc. Inst. Vitreous Enamellers*, **11**, p .97.

yearly consumption of frits is about 700 to 900 tons.

Most of the Danish enamelling plants are small ones, 5 of them established after the war. All have box-muffle furnaces, only one big plant in Copenhagen having a continuous furnace. At D.F.J. there is one (older) plant for enamelling of cast iron and another (new) plant for sheet-iron enamelling. The yearly output of enamelled cast iron is about 1,000,000 kg. (pots, gas-rings, cooker-parts, casseroles and jobbing).

The sheet-iron plant produces today about 650 tons per year of enamelled sheet-iron for gas and electric cookers.

Cast-iron Enamelling

The castings for enamelling, partly made on a mechanized plant on jolt-squeeze pattern-drawn machines, partly jacket-moulded, are normally of a reasonable quality. However, close control is needed to avoid gas-porosity and inclusions in the castings. The jobbing character of the foundry makes it necessary to store the castings for enamelling for a shorter or longer time. This, of course, does not make the job easier in the enamelling shop. The average analysis of the castings for enamelling is C 3.40, Si 2.50, P 0.70, Mn 0.50, S 0.10.

The cleaning of the smaller castings is undertaken in a tumbler-Wheelabrator, supplied by Bergische Machinenfabrik, Germany.

To avoid cracked castings it had to be supplied with a rubber blanket, which was attached to the inside of the lower edge of the door, thus covering the foremost part of the belt during the operation. This is illustrated by Fig. 1. This blanket, together with a number of pieces of expanded metal, 8 in. × 10 in. mixed up with the charge gives safe tumbling with a minimum of damage, even for pots up to 9 in. diameter. For the bigger castings a +GF+ turnable-Wheelabrator is used. Both machines use angular steelgrit No. 16. In addition there are two shotblast cabins, using No. 30 grit, because this gives a quicker operation than the coarser grit.

After cleaning the castings are inspected and filled if necessary. To avoid blisters from small pinholes caused by inclusions in the castings it is practice to drill these small holes bigger so that they can be filled readily to the bottom with filler.

The castings are then groundcoated by slushing, or spraying with annealing groundcoat, except for black, which is applied direct-on after annealing at 835°C.

After drying—preferably in wheeled racks at room-temperature—the groundcoat is fired in a coal-fired muffle furnace at 840°C. It is most important that the groundcoat is applied in the correct thickness and is properly fired. The

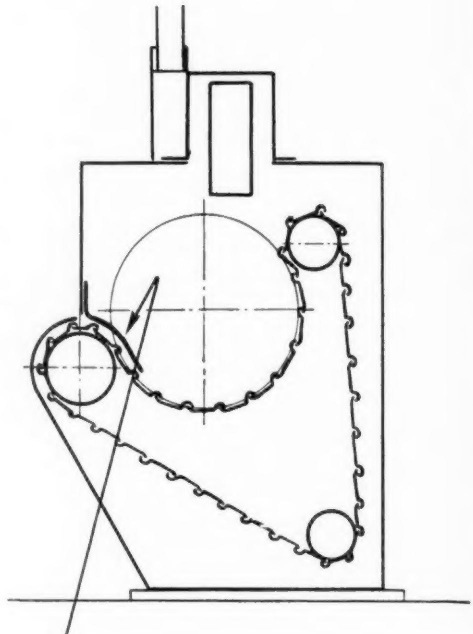

Fig. 1.—Arrangement of curtain on tumbler-Wheelabrator.

specific gravity and viscosity of the slip is under close control. A small scale and a 100-cc. measuring-bottle is placed in the workshop so personnel may control their own slip.

The covercoat is applied to the pots by slushing inside, mottling, and spraying the outside.

After drying in the racks at room-temperature (the dryer is mainly used for direct-on) the articles are fired in electric furnaces. These give superior results for covercoat-firing over the coal-fired type, and although the price of electricity in Denmark is rather high—about one penny per kW-hr.—the efficiency of the electric furnace is better than the coal-fired type.

The finished articles are inspected and recorded on control cards. The castings for respraying—about 20 per cent average—are resprayed and fired as fast as possible. However the furnaces work in 3 shifts, the sprayers only two, and the control personnel only one shift, and this causes some difficulty in getting the articles resprayed and refired at once. Reboiling of the groundcoat often takes place.

Production test runs have been carried out to try out the direct-on method of application of the covercoat. With some types of castings, *viz.* those with thin even sections, it has been quite

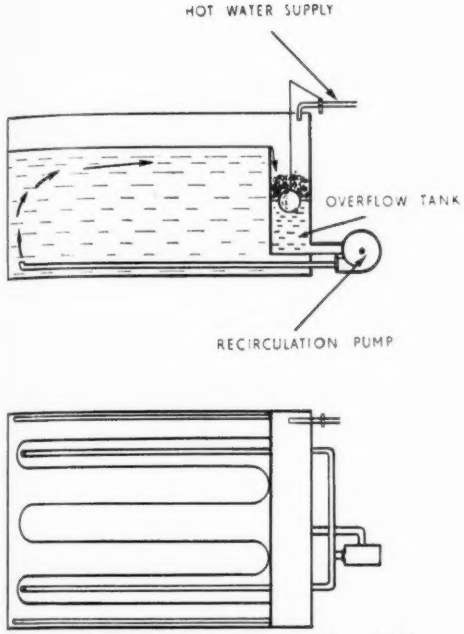

Fig. 2.—Arrangement of alkaline cleaner bath.

successful, even in A. R. titanium white, but generally it has been safer to use the annealing groundcoat.

The demand for white and pastel-shade household appliances made it necessary to alter the design of the cookers, avoiding the cast-iron tops and frames and using sheet iron instead. To balance this the company has just commenced production of a new range of cast-iron luxury pots for export. The design was by a Danish artist and the project has been very successful. From an enamelling point of view the results are very satisfactory if the castings are of good quality.

Until recently the reject percentage has been fairly high—about 30 per cent—but intense effort in the foundry to make a better job is giving remarkable results in the enamelling shop.

The Sheet-iron Enamelling Plant

The demand for gas and electric cookers in Denmark has been growing since the war and D.F.J. had to build a new plant for enamelling of sheet-iron (Fig. 3). Costing about £40,000 the building is about 10,000 square-feet plus 2,000 sq. ft. on a second floor above the pickling shop. The daylight is let in through large windows in the roof and in both sides of the building. At night 100 reflectors give very good illumination in the workshop. The floor is covered with smooth, resistant bricks which provide good conditions for transport and cleaning.

Cleaning and Pickling

The pickling department covers an area of about 25 ft. × 65 ft. The pickling cycle is as follows:

1. Alkaline cleaner 100° C. (Orthosil F2).
2. Hot rinse, running water.
3. Acid, hydrochloric 14 per cent or sulphuric 8 per cent hot.
4. Cold rinse, running water, air-agitated.
5. Nickel-dip. (Only for special purpose).
6. Cold rinse.
7. Neutralizer, soda-borax.
8. Hot-air dryer.

The acid tanks are of rubber-lined steel supplied by the British Tyre and Rubber Co.,

Fig. 3.—A view of the new D. F. J. enamelling shop.

heating is by steam coils with low-pressure steam at 0.6 atm.

The alkaline cleaner bath (Fig. 2) is of special design. To keep the surface free from foam and dirt, one end of the cleaner-tank is provided with an overflow basin, from the bottom of which the clean, foam-free liquid is returned through a pump into the far bottom end of the tank. The cleaner in the tank is thus circulated against the overflow edge of the basin, and foam, flowing dirt and grease are retained on top of the liquid in the basin and skimmed off at intervals. To keep the correct level of the liquid in the overflow basin this is provided with a float-valve-controlled hot-water supply.

Control of the baths is made twice a day, morning and noon, and the acidity and the temperature of the nickel-dip is controlled every time a basket goes in.

It was formerly normal practice to use inhibitor in the acid, but with nickel-dip this is not possible. The resulting greater wear on the pickling baskets—formerly made of plain wrought iron—now makes it necessary to use an acid-resisting material for the baskets. Normal life for a basket was about two years, and without inhibitor it is only 3 months!

Both hot sulphuric acid and cold hydrochloric acid have been used for comparison, but no difference in enamelling results was found. However—without inhibitor—the smell from the hot sulphuric acid was very unpleasant and the SO_2 in the workshop dangerous. Sulphuric acid is therefore no longer used in the plant.

Milling Practice

The milling of sheet-iron enamels is made in two 300-lb. mills, porcelain-lined and with over-head bins for charging. The slip is passed through a vibrating sieve and stored in 400-lb. drums. The mills are automatically stopped at the set time and the fineness, specific gravity and set of the slip are under close control. As in the cast-iron shop the workers are able to control the enamel slip themselves.

Application of the Enamel

The groundcoat is normally dipped on, by slushing or draining. Only the cooker tops and doors are sprayed in groundcoat because of their irregular shape. The dip-tanks are on wheels so they can easily be removed to another place or put aside.

The spray booths were specially made as portable booths with individual suction and washers. It was found that the washers retained only 99.9 per cent of the dust, so it was necessary to install pipes out into free air. However, the spray booths are very easy to move if alteration should be necessary, *e.g.*, installation of a dryer.

The spray guns are supplied with slip from overhead containers with a capacity of 10 gal. and the enamel slip is stirred by an air-motor-driven stirrer. To avoid oil and water in the compressed air, this is passed through a condenser and cooled down to 10° C. The spraying pressure can be varied from 6 atm. downwards. Normally it is used 4.5 atm., *i.e.* about 65 lb. per sq. in.

Drying

The drying of the articles is done at room temperature on wheeled racks of which there are about 30, of a light steel-pipe construction. In winter-time two air heaters blow down warm fresh air from the roof. Also in use, mainly for experimental purposes, is a small infra-red dryer of the tunnel-type, heated with 9 tube-sheathed heating elements. This is very successful for the drying of sheet-iron articles. It should be noted that in Denmark electricity for heating equals town-gas in price.

Firing

A 250-kW electric box-furnace with dimensions $4 \times 10 \times 3.5$ ft. fitted with a double fork is used for firing, working 3 eight-hour shifts (Fig. 4). Two men are fully occupied by charging. The charges

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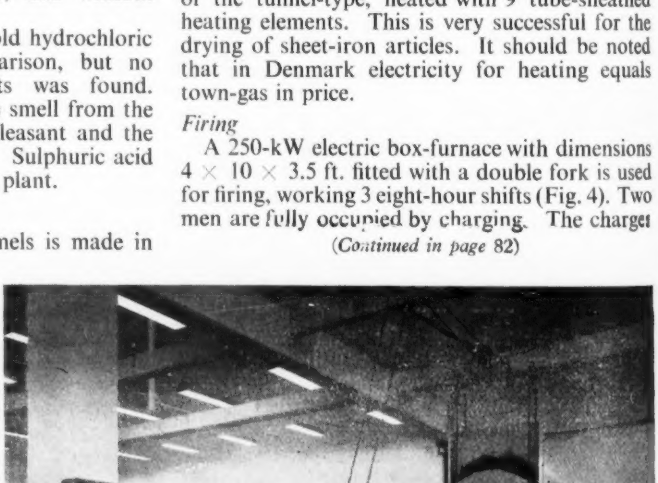

Fig. 4.—A view of the electric fusing furnace.

The Suitability of FUSION-WELDING PROCESSES for Vitreous-Enamelling

by B. TREHEARNE, B.Sc.

(A paper presented to the International Enamelling Congress)

Synopsis

Some of the factors influencing the quality of a high-grade, white vitreous-enamel finish on fusion-welded sheet-metal components are considered. The reasons for enamelling defects on the weld bead and in the H.A.Z. are discussed, and measures for overcoming them are suggested. Four methods of fusion welding are considered and the results of experiments discussed. The relationship between weld defects and enamelling defects has been established by X-ray examination. The application of post-weld hammering is considered.

Introduction

Numerous articles which are finished with a vitreous-enamel coating are fabricated from sheet-steel pressings. The pressings may be welded together subsequently to form sub-assemblies or complete articles. The two means of welding frequently used in this class of work are fusion welding and resistance welding. This paper discusses an examination of some fusion-welding processes which was carried out in order to determine the relative merits of four methods of fusion welding, which are applicable to light-gauge steel pressings.

The defects experienced in vitreous-enamel coatings on welded components are frequently in the region of the weld. The quality of the weld, the enamelling temperature and the surface condition must be related to the enamel finish required.

Experimental Procedure

The standard of finish was set for these experiments as high-grade titanium white in which there were to be no faults.

The tests were carried out on 18-s.w.g. enamelling-quality sheet which was cut to 12×3 in. in order to give a 12-in. butt weld between two pieces. The test welds were dressed flat, ground and disced. At this stage each was X-rayed to determine the weld quality. Subsequent standard dipping, pickling and cleaning processes were applied prior to enamelling. The quality of the enamel coat was judged by the defects which occurred in the weld zones, and the defects were related by means of the X-ray photographs and by metallurgical examination to weld defects and other associated factors.

Materials For Fabrication

In order to obtain a high-grade enamel finish on steel, the steel must provide a surface which may be satisfactorily wetted by the enamel during the fusing process. These conditions are generally obtained by the use of low-carbon steel sheet with a surface free from rolled-in scale and other foreign matter.

Fusion butt welds in sheet material require filler material so that the volume of the solidified weld is equal to, or greater than, the volume of the gap between the sheets to be joined, unless a very good fit-up is achieved, in which case no filler may be necessary. The filler material must provide a weld deposit which is as clean or cleaner than the parent sheet, so that in the preparation for enamelling the whole surface may be brought to a satisfactory standard of chemical cleanliness. The filler material may be provided in the form of wire or strip cut from the parent sheet. In the present examination three types of filler were used, silicon-manganese wire, Armco-iron wire and strip cut from the parent sheets. Prior to welding, each filler wire was scrubbed with wire wool to remove heavy oxide deposits; it was subsequently degreased ready for welding.

Strips cut from sheet are not considered to be as satisfactory as wire as a form of filler material because it is difficult to shear the strip thin enough from light-gauge sheets, to form a filler rod of reasonable size with respect to the weld. Further, the burrs on the sheared edges increase the difficulties of cleaning prior to welding.

The quality and cleanliness of the weld deposit jointly affect the quality of the enamel finish on the weld zone. Apparently satisfactory welds may be made which will not accept fault-free enamel finishes. Small percentages often of the order of less than one-tenth per cent of alloying elements in the steel or filler wire, adversely affect the wetting power of the enamel on the steel. Copper is a well-known example, and care must be taken to exclude it both from the filler wire and

TABLE I—*Results of Gas Analysis on Oxyacetylene-welded Sheet*

Material		Gas content in ml. per 100 gm.			
		Total	CO_2	$CO\text{-}N_2$	H_2
Welded plate	Weld metal	10.2	3.8	5.5	0.93
	H.A.Z.	5.5	1.4	3.3	0.80
Welded and ground	Weld metal	9.2	2.8	5.3	1.1
	H.A.Z.	9.1	—	—	
Welded ground and disced	Weld metal	9.0	—	—	0.80
	H.A.Z.	8.5	—	—	0.50
Parent plate		5.0	—	—	0.75

the weld preparation. From the results of the tests to be described and the cleaning processes which were applied, it is considered that Armco iron wire produced the most satisfactory weld deposit for vitreous enamelling in terms of both soundness and freedom from undesirable elements.

Selected Welding Methods

The two heat sources which were considered for fusion welding were the electric arc struck between two electrodes, one of which may be the work piece; the second was the oxyacetylene flame. The advantage of the arc over the oxyacetylene flame is that it is a much more intense source of heat and may therefore increase welding speeds and hence productivity.

The welding methods examined were:—

(*a*) Argon arc
(*b*) Atomic hydrogen
(*c*) Metallic arc
(*d*) Oxyacetylene.

Results Of Tests

(*a*) *Argon-arc welds*

Welds were made without any filler material, with strips cut from the parent sheet and with the silicon-manganese filler wire. The alloy additions to the filler wire were designed to deoxidize and clean the weld metal at welding temperature. The autogenous welds and those made without filler showed undesirable amounts of porosity on the X-ray examination. The welds made with silicon-manganese wire were sound except for the start and finish where porosity had occurred, associated with enamelling defects.

(*b*) *Atomic-hydrogen welds*

Test welds were made without filler and with filler metal cut from the parent sheet. There were no enamelling defects in those made without filler rod, and very few in the enamel over the autogenous welds.

(*c*) *Metallic-arc welds*

Two types of electrode were selected, one conforming to Class 3xx (B.S.1719:1951), the second to Class 6xx. The classification refers to the type of coating on the electrode and the Class 6xx type electrode deposits weld metal of low hydrogen content. Unsatisfactory enamel finishes were obtained from welds made with both types of electrode.

(*d*) *Oxyacetylene welds*

Two filler wires were used, the silicon-manganese and the Armco iron. The welds made with silicon-manganese wire were unsatisfactory due to some gross porosity with corresponding enamelling defects. The Armco-iron wire provided a sound deposit and no enamelling defects.

There was a possibility of the post-welding processes playing a part in the disruption of the enamel during the burning process, therefore a further experiment was carried out with oxyacetylene welds made with Armco-iron filler wire, to determine possible effects of the post-welding processes on the gas content of the samples. The results are shown in Table I. It will be seen that in general the weld metal contained more total gas than the parent material in the heat-affected zone; however, the hydrogen content in all samples was low, as also was the total gas content.

Treatment For Distortion

In general the fabrication by welding of relatively large light-gauge sheet-metal components requires care in arranging the jigging and possibly the welding procedure, in order to keep the distortion to a minimum to improve appearances. In certain cases the component may have the distortion dressed out of it by hammering after welding.

When two sheets of steel are welded together, the contraction due to cooling from the freezing temperature of steel to room temperature is localized in the weld zone. A small distance from this zone the steel will not achieve such a high temperature and consequently its change of length in the welding cycle will be less than that of the edges of the weld. The result of these changes of length coupled with the deposition of the weld metal is that the length of the weld tends to be less than the original length of the sheet, consequently there is a tendency to distortion. Hammering the weld to make it flat is a means of stretching the weld so that it is more nearly the same length as the original sheet. The cold work put into the steel necessarily makes it harder, and the article after dressing will have the correct shape with a

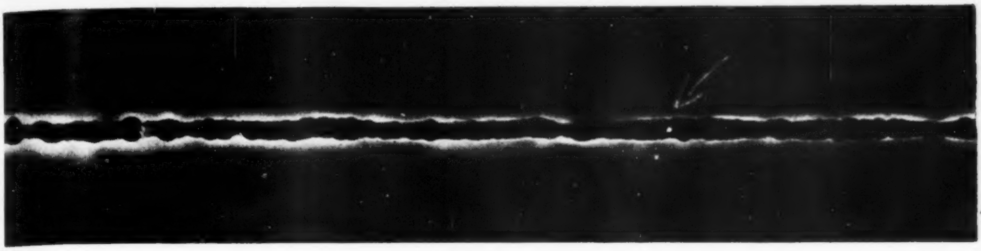

Fig. 1 (above, top) and Fig. 2 (above, bottom)

system of locked-up stresses in balance with the shape.

The furnace temperature for vitreous enamelling is greater than that necessary to stress-relieve a steel component, therefore all components are fully stress-relieved in the initial firing process. The process of stress relief does not involve permanent dimensional changes in the steel, therefore welds which were buckled owing to the shrinkage processes explained earlier, will still have the same length relative to the adjacent material. It is therefore considered to be worth while hammering the welds for enamelling, unless the component is sufficiently rigid to hold the weld in shape due to adjacent bends, flanges etc.

Discussion of Results

The type of enamelling defects which were examined, occurred either over the weld or the heat affected zone. The vitreous-enamel coating contains very high residual stresses, which may lead to fracture of the surface if severe inequalities of stress develop within it. It is therefore very important that the molten enamel shall adequately and uniformly wet the steel surface, and that during solidification it is not broken by the evolution of gases from surface reactions, or by gases coming out of solution in the steel, or by gases from porosity in the weld metal, since any of these events will cause a defect in the enamel which will not heal properly.

The surface conditions necessary to fulfil these requirements are chemical cleanliness and freedom from foreign matter, such as particles of oxide or slag. The possibility of embedded particles of grinding materials was considered, and while particles of grit may occasionally be left behind, the grinding wheel bonds were in general unlikely to cause gas evolution at temperatures as high as those used for enamelling. The results of the gas analysis in Table I show the total gas volumes extracted from the surface of the samples and from the metal. The results confirmed the fact that embedded grinding materials were not playing a significant part. Although the hydrogen content after grinding was slightly higher than in the other samples it was acceptably low, further, the total gas content of the unground weld was greater than that of the welds in the subsequent conditions. It was concluded from this experiment that the evolution of hydrogen from the weld during the enamelling process, was not a direct cause of enamelling defects, and that the volumes of other gases present must be discounted because there may be reactions proceeding at the enamelling temperatures between carbon and iron oxide.

It has been shown by Evans(1) that surface reactions between a steel casting and the furnace atmosphere may be a cause of enamelling defects. Comstock and Urban(2) have suggested similar reactions between oxides in the frit and the furnace atmosphere. The majority of enamelling defects occur at the welds in fabricated articles and may be sub-divided into those occurring over the weld and those over the heat-affected zone. The former type of defects were shown to be associated with porosity in the weld. It was concluded from the examination of radiographs and enamel surfaces that if the metal wall around the pore was sufficiently thin, the gas pressure generated within

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Vitreous Enamelling in a Danish Works

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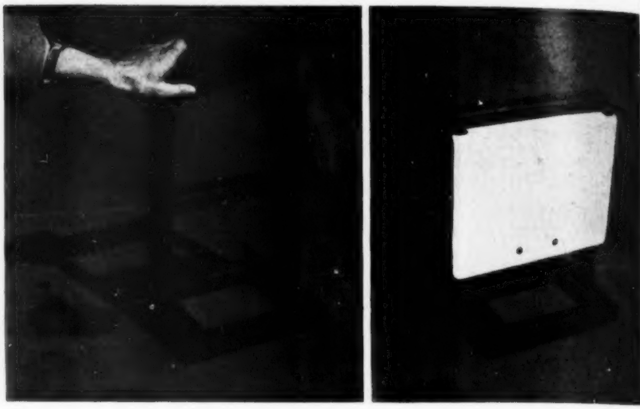

Fig. 5.—Hanging perrets for cooker parts.

are recorded by the burners and by a recording pyrometer. The firing time is set on an automatic timer, which signals when the time is complete and starts over again, when the door is closed Normal firing time is 5 minutes.

The perrets used for the sheet-iron articles are of a special design. They are made of heat-resisting chromium-nickel (25/20) sheet of 16 gauge. To obtain the maximum possible amount through the furnace and to avoid scale and dirt on the white articles as many articles as possible are fired in the hanging position.

To save time and money the hanging racks were designed with a standard base and interchangeable top parts for the different cooker-parts to be fired. The heat-resisting sheet is made into U-shaped components welded together to form a light construction. The weight of the base shown in Fig. 5 is 5 lb. and of the top 1 lb. This combination will carry a load of 10 lb. *e.g.*, two sideplates of a cooker. The hanging racks are supported by U-shaped perrets, so the total weight for a charge of 24 sideplates weighing each 5 lb. is about 100 lb., corresponding to 45 per cent of the total weight of the charge. The standard base is used for the firing of 14 different cooker-parts by combination with only 5 different tops.

Inspection

All fired articles are inspected, both in groundcoat and covercoat. The white articles are finished with one-coat white, the resprays averaging 30 per cent depending on the quality of the sheet-iron used. The rejects and resprays are recorded on control cards.

Types of Frits

A three-frit groundcoat is used which is normally fired at 830° C. Fishscaling or shinerscale has not been experienced with this groundcoat.

Only white is used for cookers, no pastel shades. The white frit is a cream-white titanium of a high gloss and good workability. The sheet-iron frits are purchased from Holland.

Economy of the Plants

All slushing, spraying, and shotblasting is done on a piecework basis; the workers earn about 4s. 6d. to 5s. an hour. Burners get 4s., pickling personnel 4s., mill-room workers about the same. Transport and inspection labour are paid 3s. 2d. minimum. The working week is 48 hours. The total number of workers in the cast-iron enamelling plant is 42 and the number in the sheet-iron plant 32. The average output of enamelled cast-iron is about 3.2 tons a day, and of enamelled sheet-iron about 2.2 tons a day. All workers are male.

The author feels that the products of his works can compete very favourably with products both of other works in Denmark and those in other countries.

Acknowledgement

The author is indebted to the managing director of The United Iron Foundries Ltd., K. F. Ulrich, for his permission to publish this paper before an international congress, and thanks the Institute of Vitreous Enamellers for their interest in Danish vitreous-enamelling practice.

Fusion Welding Processes

(*Con:inued from page* 81)

the pore at the enamelling temperature exceeded the strength of the material and caused a defect in the enamel which failed to heal up (Figs. 1 and 2). The enamelling defects near the fusion zones were mainly due to reactions of the enamel with surfaces which were not completely chemically clean. The result of the presence of foreign matter (iron oxide, grit etc.) caused defective wetting of the steel by the enamel or breakdown and reaction of the material with the enamel.

The tight clinging iron oxides formed in the heat affected zones adjacent to the weld were not satisfactorily removed by grinding, discing and pickling processes but recourse to grease burning provided satisfactory finishes.

References

(1) Evans E. R. B.C.I.R.A 1953 June 12, (4) page 586
(2) Comstock G F. & Urban S. F. Metals Handbook page 481

FINISHING NEWS REVIEW

I.M.F. COUNCIL REPORTS ON PROGRESS

Record Number of Technical Meetings held in Past Session

AT THE Annual General Meeting of the Institute of Metal Finishing held recently, the activities of the past session were reviewed in the report of the Council, which was presented by the Hon. Secretary of the Institute, Dr. S. Wernick.

While deploring the fact that there had been a reduction in the number of new members joining the Institute for the fifth year in succession, with a net loss of membership to the Institute over the past year of twenty members, the Report drew attention to the fact that the total number of technical meetings held during the session by all the Regional Branches and by the Organic Finishing Group, had risen to forty-eight, a record in the history of the Institute.

The report also referred to the fact that the total of three hundred and sixty-one delegates who had registered for the 1956 Conference in Blackpool (including twenty-seven delegates from five overseas countries) was also the highest number ever recorded for a normal Institute Conference, the International Conference of 1954 only being excluded.

Reference was also made to the work of the Education Committee, under the chairmanship of Dr. J. E. Garside, which had co-operated with representatives of the Metal Finishing Association in negotiating with the City and Guilds of London Institute the introduction of a new examination scheme leading to the metal finishing operatives practice certificate, the first examinations for which will be held next May.

Formation of Industrial Advisory Committee

In the course of the report it was stated that the Council of the Institute had had under consideration the setting up of an Industrial Advisory Committee with the object of keeping the Council informed on all relevant matters affecting the metal finishing industry, and of advising it on the nature of any action, which might be deemed necessary in the interests of the industry.

Such a committee, under the direction of Council, would also represent the Institute in providing Government Departments and other organizations, with technical information and data on which such bodies might guide their policies in relation to the industry.

In order that such a committee might function with the greatest possible efficiency, it should be representative of as wide a cross section as possible of the metal finishing industry. At the time of the Annual General Meeting this committee had not in fact been set up, but Council expressed its hope that it would be established during the course of the present session.

The report concluded with an expression of the thanks of Council to all those whose honorary activities made possible the active pursuit of the Institute's aims. It was due to the entirely voluntary efforts of those members who gave freely of their time in serving on the various committees and sub-committees, that the Institute had been able to look back on so much effective technical activity during the session.

BIRMINGHAM A.C.T. GUILD

New London Section to hold Social Evening

AT a recent meeting of Council of the Guild of Associates of the College of Technology, Birmingham, a resolution was passed to form a London Section of the Guild. There are at the present time about 35 Associates resident in or around London, 28 of these are members of the Guild and of these 24 have so far expressed support for the formation of the London Section.

At an inaugural dinner, held at the Martinez Restaurant, Swallow Street, Piccadilly, London, on Saturday, November 17, and at which the president of the Guild, Mr. D. G. Ayles, A.C.T. (Birm.), A.M.I.E.E., the immediate past-president, Mr. S. A. Jelly, A.C.T. (Birm.), A.M.I.Prod.E., and other members from Birmingham were present, an *ad hoc* committee for the London section was formed as follows: Mr. T. O. Young (Hon. Secretary), Mr. C. E. Hollis, Mr. W. F. Ratcliffe, Mr. R. L. Stevenson.

The first social evening of the newly-formed London section of the Guild will be a dinner at the Ley On Chinese Restaurant, 91, Wardour Street, London, on Friday, March 1, 1957.

Tickets, 15s. each, can be obtained from Mr. T. O. Young, 32 Bramham Gardens, Earls Court, London, S.W.5.

OPEN DAYS AT SKETTY HALL

THE British Iron and Steel Research Association will hold two Open Days at the Sketty Hall, Swansea laboratories, on Thursday and Friday, June 20 and 21, 1957, for representatives of B.I.S.R.A. member firms and users of steel sheet and strip throughout industry.

The Sketty Hall laboratories are devoted to research into problems concerning steel coatings and methods of surface preparation conducted by the Association's Mechanical Working Division. The Open Days will provide the opportunity for showing improvements in existing coating methods which have been achieved, together with developments in the use of new coating materials.

Demonstrations will be given on the recently installed experimental line for the production of PVC-bonded steel strip, and on the differential roller tinning pilot plant now being built. Other projects, including the continuous lacquering of steel strip, the use of iron-zinc and iron-tin alloys, and research into methods of gaseous deposition of metallic coatings, will also be displayed and demonstrated.

Further details and organizational particulars will be announced later.

INDUSTRIAL APPOINTMENTS

In order to co-ordinate research, development and sales service **Cellon Ltd.** have created two new posts. Mr. D. H. Grover, for the past four years technical service manager of the marine department, becomes Metal Finishes Development Manager, while Mr. E. E. Coker assumes responsibility as Development Manager for Wood Finishes.

* * *

Mr. R. T. De Poix has been elected chairman of the **Zinc Development Association** for 1957. He is the managing director of Henry Gardner and Co. Ltd., and represents the Canadian zinc producers on the Council of the Association.

* * *

Mr. J. Roy Gordon has been elected executive vice-president of **The International Nickel Co. of Canada Ltd.** He has also been elected executive vice-president of **The International Nickel Co. Inc.,** the company's United States subsidiary.

* * *

Mr. W. Dixon has been appointed deputy chairman of the board of **Wallace and Tiernan Ltd.** and Mr. B. Frisell has been appointed to the board of the company.

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Mr. J. M. Butler, M.Sc., has resigned from the position of general marketing manager of **Shell Chemical Co. Ltd.** Mr. P. J. March, B.Sc., formerly manager of the company's Egham Technical Service Laboratory, has taken up a new appointment as marketing manager (industrial), while Mr. H. G. Huckle, formerly manager, agricultural sales department, has been appointed marketing manager (agricultural). Mr. G. W. Atkinson, B.Sc., has taken up the appointment of manager, Egham Technical Service Laboratory.

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The board of **Howards of Ilford Ltd.** now consists of Mr. T. W. Howard, chairman; Mr. J. A. E. Howard, managing director; Mr. E. W. M. Fawcett, M.A., technical director; and Mr. H. P. P. Hodgkins, commercial director.

CONTINUOUS ELECTRIC ENAMELLING FURNACE

First of its kind in the country

WHAT may well constitute an augury of a future trend in enamelling was the subject of a recent ceremony at which Mr. W. S. Lewis, chairman of the Midlands Electricity Board officiated.

The occasion was the inauguration at the Blythe Bridge works of the Simplex Electric Co. Ltd. of a continuous "U" type electrically-heated enamelling furnace, installed by Metalectric Furnaces Ltd.

The first of its kind to be built in this country, the furnace is designed to enamel electric cooker parts on a continuous basis, supplementing the operation of an existing oil-fired furnace.

Firing time of components is controlled through a variable speed conveyor and the complete unit can produce 6,000 lb. gross of enamelled articles per hour.

The use of electricity for fusing vitreous enamel has much to recommend it from a technological point of view, and the design and introduction of this new furnace is a development which will undoubtedly be watched with interest.

GAS AT WORK IN INDUSTRY

Interesting Exhibition of Industrial Applications

DURING its ten day run, which finished on February 2, more than ten thousand industrialists visited the Exhibition at the Royal Horticultural Hall to see demonstrated some varied aspects of the part played by gas in industry.

The Exhibition was organized jointly by North Thames, South Eastern, Eastern, and Southern Gas Boards, and exhibits were staged by over seventy companies.

Sixteen stands were used to demonstrate the uses of gas in applications ranging from such general ones as space heating, water heating and catering, to the highly specialized requirements of shell moulding and glass working.

The flexibility and adaptability of gas as a heating and process medium of particular interest to the metal finishing industries, was the theme on several of the stands. The two rival methods of stoving paint finishes, namely by convection or by radiation, can both be equally well effected by the use of gas, and this was demonstrated on one of the stands on which were featured an infra-red radiant heat tunnel by Parkinson and Cowan Industrial Products, and a full-size camel back conveyor oven by F. J. Ballard and Co. Ltd. Articles painted in a spray booth by the Aerograph Co. Ltd. were being processed through the Ballard oven. A small box-type oven exhibiting certain new features by F. J. Ballard and Co. Ltd., was also on the stand.

There are few metal finishing processes which do not involve at some stage or another the provision of facilities for heating the liquid in a tank, and on one stand an informative display showed a number of tanks utilizing the different methods of heat application and demonstrating the versatility of gas heating. In two sharply contrasted exhibits the saving in gas, which can be achieved by correct design of the heating system, was very effectively demonstrated.

The many important applications of the direct use of flames were also the subject featured on one stand. These related particularly to the hardening of local areas of a component surface, while the important finishing technique of metal spraying was represented by an exhibit staged by Schori Metallising Co. Ltd.

When such other processes requiring the provision of exactly controllable heat input as hot-dip galvanizing and vitreous enamelling are taken into consideration, the contribution made by gas to the successful operation of a number of metal finishing processes can be seen to be of considerable importance, a fact which was very effectively high-lighted by this particularly successful exhibition.

ZINC PRODUCTION

Total refined zinc production in O.E.E.C. producer countries, *i.e.*, Austria, Belgium and the Belgian Congo, France, Germany, Italy, Netherlands, Norway and the United Kingdom, amounted to 72,368 metric tons in December, 1956, as compared with 66,109 metric tons in November, 1956. The December, 1956, breakdown into qualities is as follows:

	metric tons
High Grade and Special High Grade Zinc ...	27,248
Others (G.O.B., debased)	45,120

OBITUARY

Marston: The untimely death, at the age of 58 after a few weeks' illness, of Mr. Herbert Marston will be learned of with regret by his wide circle of friends in the finishing industry. A senior executive of R. Cruickshank Ltd., Mr. Marston was chiefly known for his work on barrel finishing, which he had pursued actively during his seven years with the company.

RESEARCH ON METALLIC SURFACES

New Organization sets up Laboratories

A NEW company operating under the name Metallic Surfaces Research Laboratories Ltd., recently inaugurated its laboratory facilities at the Market House, Uxbridge, Middlesex. The object of the research organization, which has been in existence since last October, is the investigation and development of methods of surface protection of metals and of engineering materials generally against the effects of corrosion, high temperatures and wear.

Initially, special emphasis will be given to non-electrolytic methods and, more particularly, to coatings involving diffusion or heat-treatment. This field covers, for example: carburizing, nitriding, aluminizing, chromizing, oxide coatings, vapour plating, etc.

The Laboratories undertake research projects on behalf of industrial concerns and government agencies, in addition to consulting and the development of industrial processes within their field of interest.

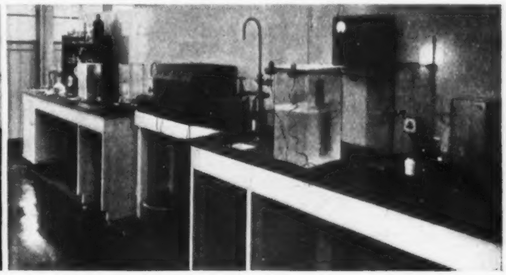
The conduct of the research is under the supervision of Mr. R. L. Samuel, Ing. Chim. A.I.M., and of Mr. N. A. Lockington, M.A., A.R.I.C., A.I.M., who are both directors of the organization and who have published many papers on metallic diffusion and related subjects.

In addition to the usual facilities for analysis, metallography and physical testing, the laboratories incorporate sections dealing with electro-chemistry, corrosion and thermal oxidation, and heat treatment.

Under investigation, at the moment, are methods of diffusion of chromium, silicon, aluminium, manganese, etc., and chemical plating techniques, applied to a variety of alloys and non-metallic materials.

Metallic diffusion processes and non-electrolytic metallic coatings are gaining an increasing industrial importance, and the Metallic Surfaces Research Laboratories offer specialized facilities for information, consulting and research in this new and fast developing branch of metallurgy.

An associated Company, Alloy Surfaces Ltd., Worton Works, Isleworth, Middlesex, carry out commercial processing of the metallic diffusion methods developed by the research laboratories.

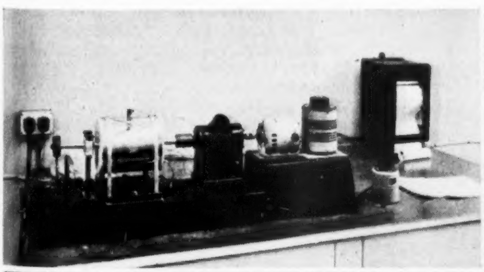


(*Above*) *Part of the analytical section of the laboratory.*

(*Below*) *Equipment for examining fatigue properties of coated specimens.*

(*Above*) *The corrosion and electro-chemical section.*

(*Below*) *Part of heat-treatment and processing section.*



OIL AND COLOUR CHEMISTS CONFERENCE

To be held in Torquay in May

THE biennial conference of the Oil and Colour Chemists' Association will take place at the Palace Hotel, Torquay, from May 21 to 25. Presented under the provisional title "Catalytic Processes Relating to the Surface-Coating Industries", the conference technical sessions will include papers by: Professor D. D. Eley, Nottingham University, on "Cationic Polymerisations"; Dr. G. C. Bond, Hull University, on "Reactions of Hydrocarbon Radicals on Metals Surfaces"; Professor C. E. H. Bawn on "The Role of Peroxide Catalysts in Coating Compositions"; Mr. F. E. Hixon, Shell Chemicals, on "The Manufacture of Paint and Lacquer Solvents from Petroleum"; Mr. C. T. Morley-Smith on "Drier Catalysis"; and Mr. R. R. Coupe, Printing, Packaging and Allied Trades Research Association, on "The Influence of Salts and Acids on the Metal Soap Catalysed Drying of Lithographic Varnishes and Ink".

LORD HAILSHAM TO OPEN ELECTRICAL SHOW

FOLLOWING recent Cabinet changes Lord Hailsham, who succeeds Sir David Eccles as Minister of Education, will now open the Sixth Electrical Engineers' Exhibition at noon on Tuesday, April 9, 1957, at Earls Court, London.

It is particularly appropriate that the Minister of Education should open the Exhibition since one of its main features will be a 7,000 square feet exhibit devoted entirely to the subject of education in Britain's Electrical Industry. Among Services, Government Departments, Industrial Organizations and individual firms who will take part in this feature are the Electrical Contractors' Association, the Electrical Trades Union, the Royal Navy and several Technical Colleges. Another feature will be an Employment in Industry Exhibit which will be devoted to showing openings in the electrical industry.

The 1957 Exhibition will occupy more than 330,000 square feet and more than 380 exhibitors are taking part.

There will be strong support in the nature of overseas buyers who will be attending. Already buyers from as far afield as India, Canada, the United States as well as Europe and South America and all parts of the British Isles, have written to the organisers to say they would be at Earls Court in April.

NICKEL IN 1956

In a statement on the nickel in industry in 1956, Dr. John F. Thompson, chairman of the International Nickel Co. of Canada Ltd., said that while the quantity of nickel available for the nickel-plating industry during 1956 was somewhat greater than in 1955, the demand continued to exceed the supply as was the case in other industries. Among the new developments in this field during the year was the application of "levelling-type" bright-nickel deposits to critical items of textile mill equipment requiring hard, smooth corrosion-resisting surfaces. Electrodeposited nickel has continued to be a market of pre-eminent importance in Europe, despite the increasing challenge offered by aluminium and stainless steel.

COMPANY NOTES AND NEWS

Borax Consolidated Ltd., operating subsidiary of Borax (Holdings) Ltd., have acquired research laboratories at Tolworth, in Surrey, to provide facilities for a staff of 50 chemists.

These new laboratories, together with those at Belvedere, Kent, provide room for a greatly expanded programme of research in boron chemistry and other fields.

* * *

The **Minnesota Mining and Manufacturing Co. Ltd.** have made a 10 per cent. reduction in the price of Resinite papers and cloths. Prices of Resin-bond products are unchanged, while for Glue-bond products and cloths increases vary from 2½ per cent. to 10 per cent.

* * *

Air Control Installations Ltd. have opened a new branch office at Newcastle. The address is Cross House, Westgate Road, Newcastle-on-Tyne 1. Telephone: 28861.

* * *

Cooper and Co. (Birmingham) Ltd. have acquired the whole of the share capital of James Farrer and Sons Ltd., Devonshire Works, Division Street, Sheffield.

Cooper and Co. are well known as manufacturers of felt polishing bobs, calico polishing mops, all grades of technical and industrial felts and the "Croid-Cooper method of machinery installation".

James Farrer have been established since 1866 and manufacture polishing and grinding machinery and equipment. The new directors of James Farrer, all active directors of Cooper and Co. are E. F. Bensly, chairman and managing; N. W. Hailey, secretary; and H. R. Walford.

* * *

As a result of higher manufacturing costs **British Titan Products Co. Ltd.** have found it necessary to increase the prices of their titanium pigments. These increases which vary between £10 and £15 a ton cover Rutiox, Anatase, and Titanium White and came into effect on February 1.

Another increase which came into effect at the same time was the surcharge on small deliveries, which is 5s. per cwt. for deliveries below 5 cwt. and 2s. per cwt. for those between 5 and 10 cwt.

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The manufacturers of mobile dust-free shot-blast machinery, **Vacu-Blast Ltd.,** have established a company in France. The address of this company, known as Société Vacu-Blast (France), is 46, Rue Anatole France, Levallois-Perret, Seine.

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The Belfast branch office of **Honeywell-Brown Ltd.** has moved to much larger premises at 296 Albert Bridge Road, Belfast. The new office is fully equipped to deal with all enquiries for industrial instrumentation, heating and air conditioning controls, and precision switches.

APPRENTICE PRIZEGIVING

At the annual apprentice prize-giving of George Kent Ltd., Luton, Beds, held on January 7, the guest speaker was Sir John Burgoyne, O.B.E., J.P. During 1956 the company had 127 apprentices under training. The winners of the first prizes in each group were: the Commander Kent Challenge Cup: J. C. Keeling; the Sir Walter Kent Prize: E. L. Amiss, seen below receiving his prize from Commander P. W. Kent; the R. W. Bedford Challenge Cup: R. Stratford; the Grout Prize: M. J. Mansbridge. An exhibition of work and handicraft by the apprentices, held in conjunction with the prize-giving, attracted much attention.

TECHNICAL BOOKSHELF

"The Protection of Structural Steel." A collection of the views of authorities from six countries. Published by the Society of Chemical Industry, Publications Department, 14 *Belgrave Square, London, S.W.*1. *Price* 30*s.*

IN April, 1955, the Corrosion Group of the Society of Chemical Industry organized a Symposium on the Protection of Structural Steel. Papers were presented by authors from Belgium, France, Great Britain, Holland, Sweden and U.S.A., and were discussed over two days in London by a gathering which included eminent authorities from several countries.

The eleven papers presented have already been published in the *Journal of Applied Chemistry* and *Chemistry and Industry* but they have now been collected together in one volume together with the report of the contributions to oral and written discussion and with a detailed summing up prepared by Dr. J. C. Hudson.

The papers included are: "Painting and Protection of Steel Structures", by F. Fancutt (Great Britain); "Current Good Painting Practice for Steel Structures in the U.S.A.", by J. Bigos (U.S.A.); "The Preservation of Steel on Gas-works in Great Britain" by L. A. Ravald (Great Britain); "Protection Problems in Chemical Factories", by F. R. Himsworth (Great Britain).

"Practical Experience with Sprayed Metal Coatings", by W. E. Ballard and F. A. Rivett (Great Britain); "The Use and Weldability of Aluminium-Sprayed Steel", by H. F. Tremlett and W. A. Johnson (Great Britain); "The Principles of Protective Painting", by G. Dechaux (France); "The Physical Examination of Paints in Relation to their Practical Performance", by H. W. Talen (Holland); "The Formulation of Priming Paints for Structural Steel", by J. C. Hudson and J. F. Stanners (Great Britain); "Exposure Tests of Paints and Zinc Coatings in Sweden", by K. F. Tragarth and P. Nylen (Sweden); and "Results of Researches of the Belgian Corrosion Committee", by M. van Rysselberge and D. Bermane (Belgium).

These papers cover a very wide field of experiment and practical experience and much other useful material was contributed during discussion. The combination of the papers and discussion with Dr. Hudson's summing-up and a full index makes the complete volume a valuable work of reference for those concerned with the maintenance of steelwork exposed to the atmosphere out of doors or in factories.

"High-purity Water Corrosion", published by the American Society for Testing Materials, 1916 *Race Street, Philadelphia* 3, *Pa., U.S.A.* 56 *pp., Price* $1.75.

RISING concern with corrosion problems makes this symposium of interest to corrosion engineers, nuclear engineers, and scientists interested in the phenomena associated with high-purity water and its corrosive effects under various conditions.

Contained in the book are the following papers: "The Preparation and Maintenance of High-purity Water", by F. N. Alquist; "The Use of Water in Atomic Reactors", by H. W. Huntley and S. Untermeyer; "Influence of Water Composition on Corrosion in High-Temperature, High-purity Water", by D. M. Wroughton, J. M. Seamon and P. E. Brown; "Effect of Material Composition in High-temperature Water Corrosion", by A. H. Roebuck; and "Special Corrosion Study of Carbon and Low-alloy Steels", by R. U. Blaser and J. J. Owens.

The volume is illustrated with graphs, diagrams, and photographs. Four of the five papers presented include bibliographies.

"Methods for Chemical Analysis of Metals", published by the American Society for Testing Materials, 1916 *Race Street, Philadeplhia* 3, *Pa., U.S.A.* 640 *pp., Price* $8.00.

THIS 1956 edition is the first complete revision of the volume since 1950. This publication is essentially a part of the Book of ASTM Standards and contains all ASTM methods for chemical analysis of ferrous and non-ferrous metals and alloys, including spectro chemical procedures. It complements Part I on Ferrous Metals.

There are ten completely new methods and recommended procedures in the book. These include chemical analyses for electronic nickel and titanium and two important recommended practices in the field of spectrochemical analysis. In addition, ten standards have been substantially revised since 1950. The book contains 42 methods of analysis including four spectrochemical procedures.

There are five recommended practices and one specification. Some of the standards contain diagrams of apparatus and pertinent charts.

The standards included in this book were formulated by Committee E-3 on Chemical Analysis of Metals and Committee E-2 on Emission Spectroscopy. The methods are intended for referee purposes in marketing and purchasing of metals and alloys according to specifications. They are planned to provide satisfactory means for judging adherence of materials to specifications.

MILLING AND SMELTING OF NICKEL ORES

Second Film in the Inco Saga

"Milling and Smelting the Sudbury Nickel Ores", the second film in the series produced by the International Nickel Company of Canada Ltd., dealing with the nickel industry, was publicly shown on February 7 at Thames House, the head office of the Mond Nickel Company Ltd.

Filmed on location at Copper Cliff and other Company plants in the Sudbury area of Ontario, Canada, the 54-minute film depicts, in a most graphic and effective manner, the intricate processes by which nickel—and 13 other elements—are extracted from the Sudbury ores. This film, in Eastman colour, covers all the stages in Inco's milling and smelting operations, commencing where the first film in the series, "Mining for Nickel", ended. The new film follows the reduction processes from the time the ore is magnetically separated into massive and disseminated ores until the metals are either shipped to industry or despatched to Inco's refineries.

The film shows the unique processes developed to obtain the greatest yield from the ores, including sintering, flotation, roasting in four-storey high roasters, cooling and oxygen flash smelting. A highlight of the film is a glimpse of the world's largest convertor aisle, where Bessemer convertors work continuously. The intricacies of the oxygen flash smelting furnace are explained in an animated sequence. Developed by Inco engineers, it is a furnace in which copper concentrates smelt themselves, the heat required is obtained entirely from burning the sulphur and iron in the concentrates with pure oxygen.

Meetings of the Month

FEBRUARY 15

Institute of Metal Finishing (Sheffield and North-East Branch). Dinner and Dance at the Grand Hotel, Sheffield, at 7 p.m. for 7.30 p.m.

FEBRUARY 16

Oil and Colour Chemists' Association (Scottish Junior Sub-Section). "Stoving Finishes", by Mr. Rogers, B.Sc., at More's Hotel, India Street, Glasgow, at 10 a.m.

FEBRUARY 18

Institute of Metal Finishing (London Branch). "Soldering of Metallic Coatings", by G. L. J. Bailey, Ph.D., D.I.C., F.Inst.P., W. Marchand, A.R.I.C., and C. J. Thwaites, B.Sc.(Eng.), A.R.S.M., at the Northampton Polytechnic, St. John Street, London, E.C.1, at 6.15 p.m.

FEBRUARY 19

Metal Finishing Association (Birmingham Luncheon Club). "Considerations of an Engineering Buyer when placing contracts for outwork plating capacity", by G. A. Granger, at the Farcroft Hotel, Rookery Road, Handsworth, Birmingham 21.

FEBRUARY 20

Society of Chemical Industry (Corrosion Group). "Theory and Practice in Potential Measurements for Cathodic Protection", by P. W. Heselgrave, at 14 Belgrave Square, London, S.W.1, at 6.30 p.m.

FEBRUARY 22

Institute of Metal Finishing (Sheffield and North-East Branch). "Difficult Plating Processes as Typified by the Electrodeposition of Manganese and Aluminium", by Professor J. W. Cuthbertson, D.Sc., F.I.M., A.M.I.E.E., at the Grand Hotel, Fitzwilliam Room, Sheffield at 7 p.m.

FEBRUARY 28

Institute of Vitreous Enamellers (Midland Section). "Some Aspects of Cast-iron Enamelling and its Future in the Cooker Industry", by J. Bernstein at the Birmingham Exchange and Engineering Centre, Birmingham, at 7.30 p.m.

Oil and Colour Chemists' Association (Scottish Section). "The Preparation, Properties and Rheological Investigation of Thixotropic Paint Systems", by D. J. Doherty and R. Hurd, at More's Hotel, India Street, Glasgow, at 7.15 p.m.

MARCH 5

Institute of Metal Finishing (Midland Branch). "Chemical Polishing of Metals", by F. H. Wells, A.R.I.C., at the James Watt Memorial Institute, Great Charles Street, Birmingham 3, at 6.30 p.m.

MARCH 6

Institute of Metal Finishing (Scottish Branch). Debate on "That This Meeting is of the opinion that for decorative work bronzed and oxidized finishes will prevail against all others", at the Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank Crescent, Glasgow, at 7.30 p.m.

MARCH 7

Institute of Metal Finishing (North-West Branch). "Modern Painting and Stoving Techniques Including Flow Coating", by J. J. Stordy, B.Sc., and W. G. A. Appleton, A.M.I.Mech.E., M.Inst.F., at the Engineers' Club, Albert Square, Manchester, at 7.30 p.m.

MARCH 14

Oil and Colour Chemists' Association (Scottish Section). "Some New Aspects of Titanium Oxide Performance in Surface Coatings", by J. G. Campbell, B.Sc., at More's Hotel, India Street, Glasgow, at 7.15 p.m.

MARCH 18

Institute of Metal Finishing (London Branch). "Recent Developments in Copper Plating", by D. E. Weimer at the Northampton Polytechnic, St. John Street, London, E.C.1, at 6.15 p.m.

MARCH 27

Institute of Metal Finishing (Organic Finishing Group). "Protection of Metal by Use of Tannins", by T. White, B.Sc., Ph.D., A.R.I.C. Joint meeting with the London section of the Oil and Colour Chemists' Association at the Royal Society of Tropical Medicine and Hygiene, 26 Portland Place, London, W.1, at 7 p.m.

FINISHES IN ACTION

Ever popular Shop Window at Olympia

WHILE the protective role of finishes applied to metals is a function whose importance must never be underrated, it is their capacity for enhancing so notably the appearance of commodities which makes metal finishes such a powerful sales force.

The *Daily Mail* Ideal Home Exhibition, which is open at Olympia this year from March 5 to 30, has shown itself to be one of the most popular events of the year. It provides a unique opportunity for a very wide range of consumer goods to be displayed under practically ideal conditions and on a strongly competitive basis.

During the three weeks that the exhibition is open some millions of customers survey the goods on show and carry away with them an inclina- to purchase those few commodities which for one reason or another have excited their interest.

In stimulating the choice between two competitive commodities of approximately equal merit, propriety of design and attractiveness of finish are of very considerable importance. To all those concerned with the selection and application of metal finishes, a visit to the Ideal Home Exhibition is an illuminating, as well as a pleasurable exercise, particularly if an attempt is made to analyse exactly why the style and finish of one particular article appears more attractive than does that of another. The lesson learned from such an analysis should do much towards increasing the sales appeal of a wide range of finished articles to an ever more finish-conscious public.

Metal Physics of Corrosion

April Meeting

The Metal Physics Committee of The Institute of Metals is organizing a Discussion on "The Metal Physics of Corrosion and Oxidation", to be held at Church House, Great Smith Street, London, S.W.1, on the afternoon of Tuesday, April 30, starting at 2.30 p.m. The discussion will be opened by Dr. O. Kubaschewski (National Physical Laboratory) and Dr. C. Edeleanu (Tube Investments Research Laboratories).

Visitors will be welcome; tickets of admission are not required.

SUMMER SCHOOL ON CORROSION TESTING

It is intended to hold the fourth Summer School on Corrosion from July 15 to 19 this year, at the **Battersea Polytechnic,** London, the theme being "Corrosion Testing". A series of lectures by a panel of lecturers who are authorities on the subject will be given on the corrosion testing of metals, alloys, metallic and paint coatings, etc.

The lectures will be supplemented by a demonstration of corrosion testing apparatus and methods, and by visits to laboratories engaged on corrosion testing. Applications to attend these lectures should be made to the Secretary (Corrosion Testing), Battersea Polytechnic, Battersea Park Road, London, S.W.11.

TRADE and TECHNICAL PUBLICATIONS

"Chemical Polishing Solutions": Two new data sheets on Phosbrite 150 and Phosbrite 159 have been published by the manufacturers Albright and Wilson Ltd., 49 Park Lane, London, W.1.

They state that each of the solutions is suitable for all grades of aluminium from commercial to super purity. The solutions will also polish all the alloys of aluminium with the exception of the high-silicon content die-casting alloys.

Phosbrite 150 is a slow-acting solution which removes about 0.00075 in. of metal in a three-minute polishing period. It is suitable for use on aluminium that is only lightly scratched, and gives good results on aluminium that has been mechanically polished previously.

Phosbrite 159 is an up-to-date version of the Alupol solution which is widely used on the Continent. It is a rapidly-acting solution which removes 0.003 in. of metal during a three-minute polishing period, and is very effective for polishing aluminium which is badly scratched or has other surface imperfections.

"Nickel Bulletin": October-November 1956. The issue of this journal published by The Mond Nickel Co. Ltd., Thames House, Millbank, London, S.W.1, includes a comprehensive survey of nickel developments in Canada (with additional notes on world conditions in the nickel industry).

The section concerned with heat- and corrosion-resisting materials contains abstracts reporting further study of the phenomenon of corrosion by vanadium pentoxide, and a review of information on atmospheric corrosion contributed to the 1955 meetings of the American Society for Testing Materials.

"Lead In The Ceramic Industries": This new technical data book has been published by the Lead Industries Association, 60 East 42nd Street, New York 17, N.Y., U.S.A. It is designed to meet a need created by the wider use of lead in ceramics resulting from the trend to lower firing temperatures, new metals like aluminium to be porcelain enamelled, new developments in ceramics for electronic applications, and many other new conditions where lead is helpful to the ceramist.

The book describes the lead products used in ceramics and gives their properties of interest to the ceramist, including the more important phase diagrams involving lead compounds. It explains the properties imparted by these compounds to the various forms of ceramics. Detailed sections describe the use of lead compounds in glazes, glass, porcelain enamels for iron, steel and aluminium glass decorating colours, ceramic bodies such as low dielectric, piezoelectric and others, and miscellaneous applications.

A section is also devoted to good materials handling practice and to the adequacy of future lead supplies.

"Cellon Bulletin": The January issue of this magazine published by Cellon Ltd., Kingston-on-Thames, Surrey, gives its usual review of the latest developments in paints and protective finishes.

One article deals with The Express Lift Co. and explains the problems involved in the production of the panels of the cars which, being flat, act as mirrors and necessitate an absolutely blemish-free finish. Information is given on the finishing procedure for these panels and it is accompanied by illustrations showing the mirror-like finish obtained.

"Hydrabrasion": This booklet published by British Vapour Blast Ltd., Rose Hill, Coalbrookdale, Nr. Ironbridge, Shropshire, is a summary of their publication "The Theory and Practice of Hydrabrasion".

It describes Hydrabrasion from its earliest form as a vapour blast in which water-borne abrasive was discharged at high velocity from an injector gun using compressed air as an accelerator and also its uses in surface preparation, final finishing and removal of tooling burrs.

"Barrel Finishing Equipment": A new 20-page general catalogue of Globe barrel finishing equipment and supplies has been issued by the Globe Division of Casalbi Company, Box 411, Jackson, Michigan. It includes information on all different types of abrasive and burnishing media, and necessary compounds. It also lists and comments on the six variables in barrel finishing and includes before and after photographs of parts which have undergone deburring, polishing, burnishing, radii forming, rubber deflashing and descaling.

"The International Enamelist": This quarterly journal published by the International Division, Ferro Corporation, 4150 East 56th Street, Cleveland 5, Ohio, U.S.A., contains many articles of interest for people connected with the vitreous-enamelling industry.

These include "A New Era for Enamelling Furnaces" in which convection takes its place with radiation as a source of heat control in the enamelling furnace of the future; mass production of porcelain-enamelled utensils; formability and processing of metals.

"De-rusting and Passivating": A leaflet has been produced by Walterisation Co. Ltd., Purley Way, Croydon, which describes the company's Deran process.

The advantages claimed for the processes are that although efficient as a de-rusting media they are only mildly corrosive and do not give off dangerous or unpleasant fumes; and they contain chemicals which promote the dissolution of rust and scale and simultaneously act as surface passivators and rust inhibitors.

The effect of the treatment is to remove oxide films such as rust and scale, which of themselves are unsuitable under paint, enamel, or other organic finishes. Also, the passive surface prevents the incidence of further rusting in the event of a delay between derusting and painting.

"Wash Primers": A leaflet has been produced by British Paints Ltd., Portland Road, Newcastle-upon-Tyne 2, that describes their "Torpedo' wash primer for aluminium and other non-ferrous metals.

Information is given on the primer itself and its properties, as well as instruction and recommendations for its use. It may be used with either brush or spray. Following this details are given of the painting procedure to be used after the primer depending on whether the material is to be exposed to marine conditions, normal conditions or if an aluminium or stoving finish is required.

"Tin and Its Uses": The current issue of this quarterly journal published by the Tin Research Institute, Fraser Road, Perivale, Greenford, Middlesex, is largely devoted to developments in the field of organotin compounds. Organotin compounds are already finding uses in plastics as stabilizers and in paints both as stabilizers and anti-fungal agents.

It is shown that tributyltin acetate performs better as a fungicide in emulsion paints than the usual agents.

A practical tinner gives a detailed account of the technique he uses to overcome the de-wetting tendency sometimes occurring in the tinning of steel wares. Other items of metallurgical interest relate to some early screw stoppers for bottles, a new film about pewter from Germany, and a strange case of creep in tinfoil.

Latest Developments in PLANT, PROCESSES AND EQUIPMENT

Automatic Fan-control Unit

A FAN-CONTROL unit (Fig. 1) which automatically switches off the fan when the spray gun is no longer in use, and switches it on again when spraying re-starts, is being produced by Alfred Bullows and Sons Ltd., Long Street, Walsall.

The unit is simple in construction. A slight local restriction is fitted in the main air-line feed to the spray guns on the booth. The airflow caused by the spraying operation induces a slight pressure drop on the downstream side of the restriction, and the variation in pressure on either side of this is used to actuate a diaphragm cylinder, which in turn controls an air-feed valve to a small reservoir, and in turn to a pressure switch which completes the circuit for the fan motor.

A permanent bleed to atmosphere is fitted in the reservoir itself, so that when spraying stops, the pressure in the reservoir gradually decreases until the pressure switch breaks contact. The rate of bleed is adjustable, giving a variable time lag before the fan motor stops. Normal setting is for a delay of $1\frac{1}{2}$ to 2 minutes after spraying ceases, and this prevents the fan cutting in and out repeatedly if the operator triggers at the end of each stroke, or otherwise stops spraying for short periods to change position or to clear a gun stoppage. It also ensures the removal of overspray which may remain in the booth after spraying ceases.

When the spray gun is used again the fan starts up automatically within two seconds.

The electrical switchgear for use with the fan-control unit must be suitable for automatic operation, and will normally need to be changed to the automatic type when the unit is installed.

High-speed Drive for Carbide Burs

THE use of carbide burs for giving a smooth finish to many engineering products has become established practice in the past few years.

The cemented-carbide bur has teeth which are usually more closely spaced than is usual with high-speed-steel burs but the high degree of toughness achieved in these tools is accompanied by a measure of brittleness and more care must be taken with them than with steel burs.

The speed at which they are operated is a decisive factor in the economic use of these burs. While, for use on mild steel a $\frac{3}{8}$-in. high-speed-steel bur or rotary file gives satisfactory results at 2,750 r.p.m., a carbide bur of the same diameter requires 24,000 r.p.m. to give maximum benefit, when a four-fold increase in the rate of material removed may be expected. At too low a speed, undue shock will be transmitted to the teeth of the bur, which is a major cause of breakage.

Rotary files or burs may be operated equally well with either electrically or air-powered tools which give sufficient r.p.m. to correspond with the diameter of the tool. For the operation of carbide

(*Continued in page* 92)

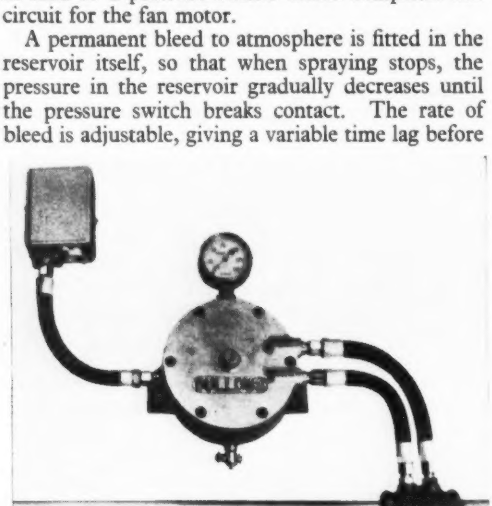
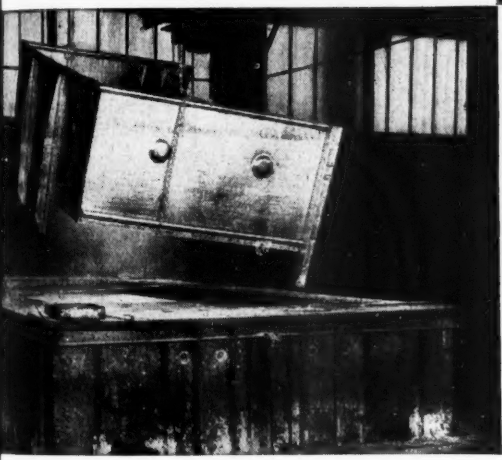


Fig. 1 (*Above*).—*Automatic fan-control unit.*

Fig. 2 (*Right*)—*High-speed drive for carbide burs.*

NOT TOO BIG



For Hot Galvanizing

Hot galvanizing is a remarkably versatile rust-proofing process. For buckets, tanks, wire, window frames, bins and countless other items of everyday life, its uses are well known. But few realize how large are many of the articles hot galvanized. Three-storey building stanchions, 2,000-gallon cylinders, road tankers — these things hot galvanizing takes in its stride. But that is not all. Much larger objects are also given long term protection by hot galvanizing the component parts separately and assembling them afterwards. Take the railway goods waggon (bottom left). Measuring 17′ 6″ long by 8′ 6″ wide, this wagon is designed for dipping in four parts — an underframe and three body-sections — which are later bolted together. For T.V. masts the same technique is used. Like all B.B.C. television masts, that at Sutton Coldfield (top right) is built up of hundreds of pre-galvanized sections to ensure the longest possible life without attention. With suitable designing, the sky is the limit!

Hot Dip Galvanizers Association

The Hot Dip Galvanizers Association, a non-trading body, welcomes enquiries. Write to 34 Berkeley Square, London, W.1
Tel. Grosvenor 6636

Member of the Zinc Development Association

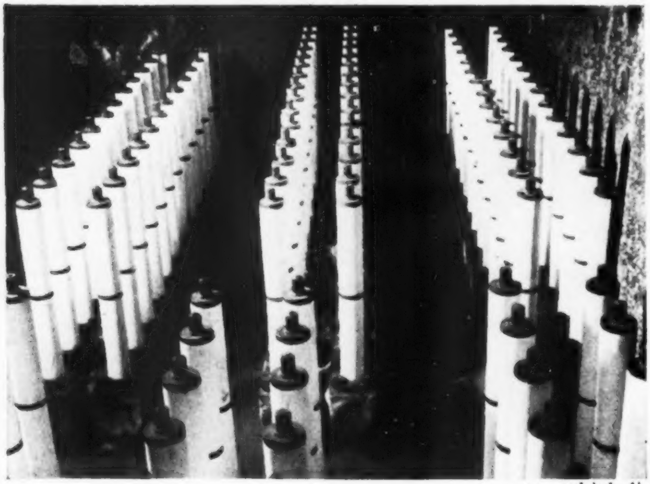


Fig. 3.—Ceramic cylinders used for diffusing air and gases in liquids.

burs, the Consolidated Pneumatic Tool Ltd., 232 Dawes Road, London, S.W.6, have produced an electrically-powered Hicycle grinder (Fig. 2) to operate at 25,000 r.p.m. Attention has been paid to allowing as short a grip as possible to give accurate control, while an offset spindle permits flexibility for intricate work in inaccessible places.

Ceramic Aeration Diffusers

A METHOD of diffusing air and gas in liquids by means of ceramic cylinders has been announced by Aerox Ltd., Scottish Industrial Estate, Hillington, Glasgow, S.W.2.

The use of these ceramic cylinders (Fig. 3) is claimed to reduce reaction time by providing a denser stream of small air bubbles and therefore a larger surface of gas contact for reaction purposes.

The ceramic material, Porsilex, possesses the essential characteristics of porcelain and is available in a range of pore sizes from 200 to 10 microns average diameter. It is usually supplied in cylindrical form for diffusion purposes, although tiles, both circular and rectangular, are also available. Suspension fittings for the elements are supplied in a wide variety of materials including ebonite, plastic, bronze, brass and stainless steel.

Carbon Ejectors for Corrosive Liquids

THE universal suitability of carbon for handling all types of corrosive liquids has led to the development of carbon ejectors or siphons for emptying tanks of pickling liquor and similar corrosive fluids.

Pickle tanks are generally situated below ground level or are not provided with side outlets so that the acid must be emptied from the top of the vessel by means of a pump or ejector. Tanks are usually emptied at weekly or monthly intervals and a pump, if fitted, would only operate for very short periods with long intervals of idleness. This is wasteful and costly since a pump suitable for handling dirty pickling liquor is unlikely to be adaptable to another duty.

To overcome these problems a range of carbon ejectors both water- and steam-operated types have been manufactured by Powell Duffryn Carbon Products Ltd., Springfield Road, Hayes, Middlesex. The ejectors (Fig. 4) are capable of handling all corrosive fluids, and particularly waste pickling liquors heavily contaminated with crystals, scale, etc., at high discharge rates. With the water-operated types, low-pressure water is suitable and waste liquor can be discharged directly to the neutralization plant or to waste.

The ejectors are robust both mechanically and thermally, there are no moving parts and all carbon parts are completely protected by the cast-iron casing.

(*Continued in page* 94)

Low-frequency Ultrasonic Generator

A COMPOSITE low-frequency ultrasonic generator, which provides suitable outputs for driving a 50-watt ultrasonic drill, a soldering iron or a tinning bath from a single source has been produced by Mullard Ltd., Mullard House, Torrington Place, London, W.C.1.

The generator will be useful in applications where drilling, tinning and soldering operations are performed, since it enables a compact dual- or triple-purpose installation to be achieved.

Two outputs are provided: one for the drill, the other for the soldering iron or tinning bath. The former is transformer-coupled to the transducer, the latter capacity-coupled.

The generator, which also provides a suitable supply for heating the bit of an ultrasonic soldering iron, is 12 in. x 10 in. x 11 in. high.

Unlike conventional drilling methods, in which a rotary motion is imparted to the cutting tool, the tool of an ultrasonic drill vibrates with a reciprocating motion on a finely granulated abrasive material, suspended in water, which is interposed between the tool and the workpiece. Since the shape of the hole produced closely follows the shape of the tool, holes and patterns of any shape, no matter how intricate, can be cut.

The technique is not confined to drilling and piercing; it can be applied to most other machining operations, including shaping, grinding, polishing, etc. Great accuracy and very fine surface finishes are possible using appropriate abrasives.

Ultrasonics offer a quick method of tinning using soft solders and without a flux. Liquid solder in the tinning bath is agitated by low-frequency ultrasonic energy, which causes intense cavitation to occur. The voids produced collapse rapidly, and any plane surface immersed in the bath is subjected to a large number of erosion implosions which disrupt the refractory oxide present on aluminium or its alloys, and make possible the adhesion of the solder.

The principle of the soldering iron is identical.

Fig. 5.—Abrasion Tester.

Abrasion Testing Equipment

A PRECISION-BUILT instrument, the Abraser, designed to evaluate the resistance of surfaces to rubbing abrasion manufactured by Taber Instrument Corporation, 111 Goundry Street, North Tonawanda, N.Y., U.S.A., is now available in the U.K. through Funditor Ltd., 3 Woodbridge Street, London, E.C.1. Its range of application includes tests of painted, lacquered, electroplated surfaces and plastic-coated materials, also metals, leather, rubber and linoleum.

The rotary rub-wear action is the result of dual abrading wheels, one rubbing the specimen from the centre outward and the other from the outside towards the centre (Fig. 5). The abrasion marks are in the form of two arcs criss-crossing each other and covering an area of approximately 30 sq. cm. which is satisfactory for rating most materials.

An exclusive feature of the Abraser is that the wheels traverse a complete 360-deg. circle on the specimen surface revealing abrasion resistance at all angles relative to the weave or grain of the material.

Two sets of precision stainless-steel weights of 250 and 750 gm. are furnished, which, in addition to the abrading arm itself (250 gm.) provide three standard ranges of wheel pressures, 25, 500 and 1,000 gm., against the specimen. Counter-weights are also available to reduce the load to 125 gm.

Abrading wheels designed to simulate many types of abrasion on a wide range of materials are available. Resilient "Calibrase" wheels are used to abrade both hard and soft materials, including electroplating, paints, enamels and other coatings. "Calibrade" wheels are of the hard vitrified type which are best adapted for testing rubber, leather and metals.

The machine can also be set up to give information on the wear life of materials in their wet state in comparison with abrasion resistance when dry. The difference is considerable in many cases.

A wear factor is calculated which represents the loss in weight per 1,000 cycles of test under a specified set of conditions. Quantitative wear, such as that of a protective coating lacquer is indicated by the counter reading at the first sign of penetration of the material. Decorative patterns protected by a coating of transparent material are usually run to the end point where the worn appearance becomes objectionable. The counter reading then gives an overall evaluation of the wear that that protective coating will withstand. Both methods give a numerical result which is comparable with other tests made under the same conditions.

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